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with the sincere regards

of his friend

the Author.

Jas Burnley

Nov. 12. 1886.

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THE BENIGHTED FARM-LABOURER IN HUNTSMAN'S FOUNDRY.

(*See p.* 345.)

THE

ROMANCE OF INVENTION:

VIGNETTES FROM THE ANNALS OF INDUSTRY AND SCIENCE.

BY

JAMES BURNLEY,

AUTHOR OF "FORTUNES MADE IN BUSINESS," "TWO SIDES OF THE ATLANTIC," ETC.

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PREFACE.

In the following pages, some of the more romantic features of the history of Invention have been described, apart from their technical surroundings. The outline thus drawn of the world's progress presents the chief incidents of real and abiding interest connected with the subject; and it is hoped that the classifications which have been adopted, and the mode of treatment generally, will render the volume acceptable to those who have not the opportunity of diving into all the details and mysteries of the various things treated of.

The history of Invention is much more than a question of mere machinery, or of material progress. The life-stories of the inventors are alive with light and shadow. Struggles with poverty, hopes long deferred, the sudden flow of dramatic incident which precedes discovery, the realisation of a life's dream, the acquisition of fame and riches, form parts of the story just as much as the conquest over the forces of Nature, and the working out of problems.

The lives of most of our inventors have already been written, but in many cases there has been so much hard fact to set forth, that the thread of

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romance has now and then seemed to get lost. It has been thought, therefore, that by taking subject-views rather than portraits, the object of this book would be more easily attained, and that additional interest by this means might be imparted to the records of Invention.

There has necessarily been a large extent of literary labour laid under contribution in the bringing together of so many facts, but the main sources of information have been indicated in the text. Although the author's research has extended into many odd nooks and corners, no trustworthy source has been ignored; and here and there his own knowledge or inquiry has brought into prominence facts which have not before been dealt with, and which will, he believes, make the general narrative more valuable.

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THE
ROMANCE OF INVENTION.

CHAPTER I.

THE BEGINNINGS OF INVENTION.

Inventions of pre-historic Ages—The Record of the Fossil Under-World—Early Civilisation and its Splendours—The Indications in Scripture of Arts and Manufactures—Tubal Cain—Hiram and Bezaleel—Job's Metallurgic References—The Growth of Hellenic Art—Homer and the Shield of Achilles—The Genius of Archimedes—The Discoveries of the Middle Ages—Gunpowder and Printing—The Mechanical Inventor of the Seventeenth and Eighteenth Centuries—The Dawn of the Era of Steam.

IN the dawn of the world, before the recording finger of history had begun to mark the progress of time and civilisation, man's inventive faculties were chiefly exercised in providing for his comfort and safety—in devising means of protection from the elements and the attacks of wild animals. Through the long prehistoric ages, he was almost as much a creature of the fields and forests as the beasts themselves, sharing the fruits and roots of the earth with them, and only by slow degrees, as his intelligence was developed by experience and observation, daring to assume command over the rest of created things. As soon as he began to invent he took the first steps towards civilisation. He invented a covering of skins as his garment; converted shells into receptacles for holding water, so that he might satisfy his thirst more conveniently than by using the hollows of his hands; hit upon the happy expedient of obtaining fire by rubbing together two pieces of wood; and arrived at such a knowledge of the quality and fitness of stone as enabled him to manufacture his first weapons.

With the advantages which these inventions gave him, he soon advanced to still greater achievements in the way of utilising the products and forces of Nature. In the imperishable testimony of the rocks we can trace the progress of invention through the clearly-defined epochs distinguished as the Drift, the Polished Stone, the Bronze, and the Iron ages; and can discern the growth of civilisation from primeval barbarism to the period when a highly organised state of society began to exist. Here the stony record tells us of man working in flint, making himself hatchets and other implements; there that he is fashioning articles out of bone, ivory, and horn; and here that he has constructed dwellings in the hollows of the rocks, or built habitable platforms on the bosom of secluded lakes. We are enabled to follow him in some of his occupations: observing him in the excitement of the chase, hunting the smaller animals, yet in imminent peril from mammoths and other monsters; noting his 'prentice efforts in gardening and the cultivation of cereals; his first tailoring experiments, when he sewed together, with needles of bone or wood, the skins that formed his garments; his earliest ventures in navigation; his making of personal ornaments, of bone and ivory and metal; and his rude operations in grinding corn, baking bread, and cooking food.

Period glided imperceptibly into period, and civilisation and barbarism alternated (for it was not all straightforward improvement and broadening wisdom in the infancy of the world), till, at last, we reach that very undefinable period when legend and tradition had the making of what we call early history, and get at something more than geological testimony, though not always, it must be confessed, at testimony so indisputably authentic.

Through the mists of this ancient time we find the textile and metallurgic arts growing, but have no knowledge of their precise starting point; and then we see the glowing lands of the Orient forming themselves into great empires, and becoming the homes of mighty nationalities which in the intervals of war engaged themselves in extending the peaceful arts. In the splendours of this early civilisation we discern the skill of the inventor employed upon the erection of gigantic temples and monuments, palaces, and pyramids; in the manufacture of costly, though rude, fabrics; and in the melting, refining, and manipulating of metals. But the record of that distant time, so far as we get any, is too clouded with the confusion of battle for us to see clearly what the inventor is doing. We can just make out that he is working away patiently, multiplying man's resources; at one time in the interests of peace, at another for the advancement of war, even as in our own time; but that is all.

We know, however, that the ancients usually converted their inventors into gods; that Osiris, who taught Egypt the art of farming, and particularly the use of the plough, was worshipped by multitudes in the stately temples of Thebes and Memphis; that Iris, his wife, who discovered wheat and barley, shared those rites with her husband; and that in the classical mythology of ancient Greece, Hercules, Pallas Athena, Bacchus, and other gods and goddesses, were translated to Olympian heights more for the inventions with which their names were associated than for their questionable exploits in the realms of love and adventure. But, when all is done, we cannot get clear of the mists. We would gladly exchange much of our knowledge of the clash of arms of those antique times for an authoritative account of the man who made the first spinning wheel, or the first loom, or the first ship, the first pot, the first bar of iron, the first piece of sculpture, or the first painting. At the dawn of history all these things were being done, in some instances with a skill that our later civilisation has been unable to surpass, and the work of invention was considerably advanced.

Taking the Scriptural narrative itself, we do not get far before we are confronted with evidences of inventive power of a high order. In the building of the ark men were employed who were well skilled in the methods of reducing iron or copper ore into its pure state, and of forging it into bolts, and bars, and plates. And, before that time, do we not read of Tubal Cain, the son of Zillah, as the earliest "instructor of every artificer in brass and iron"? Indeed, from the days when the sons of Seth began to intermarry with the daughters of Cain, and their descendants to abuse the blessings of a patriarchal existence, a glorious climate, and a fertile soil, arts and manufactures were carried on with more or less success. The descendants of Noah practised the useful arts in the lands over which they were dispersed after the Deluge; and when, later on, the

Israelites fell under the yoke of the Egyptian oppressor, they came in contact with a proficiency in the liberal arts and sciences of which they previously had no conception. They found the subjects of Pharaoh skilled in building and architecture; acquainted with the processes of spinning, weaving, and dyeing; masters of the art of working the precious metals; proficient in agriculture, and familiar with the art of writing. Moses must have passed beneath the shadow of Karnac, and amidst the magnificence of Thebes; he must have seen those marvellous monuments of imperious mysticism, the Pyramids, and gazed at the face of the immovable Sphinx.

Proud as we are in these days of our great engineering and other feats, the ruins of the ancient civilisations of the East give an evidence of difficulties overcome which seem to be beyond the resources of modern times. Neither modern Egypt nor modern Europe would be equal to such a task, for instance, as that of building the monolith temple at Sais, in the Delta, the stones for which must have been cut from the rock in Upper Egypt, and floated down the Nile on gigantic rafts. How the immense stones which, at the height of 450 feet, crown the summit of the Great Pyramid, came to be raised to their places is a marvel even to those familiar with modern steam-power and machinery. The children of Israel carried away with them in their journey across the wilderness many artificers who had profited by the sojourn in Egypt, hard as their taskmasters had been; but they do not appear to have survived to teach their arts to their children, inasmuch as the Biblical story seems to indicate a return to their former condition in these respects rather than an advancement equal to what they had left behind in Egypt. Bezaleel was probably chosen to superintend the construction of the Tabernacle because of the skill he had learned from the Egyptians; and his assistant, "Aholiab, son of Ahisamach, of the tribe of Dan," would owe his appointment to the same reason.

But it is not for a long time after that the Bible gives indication of distinct progress in the arts on the part of the Israelites. In the days of Samuel "there was no smith found throughout all the land of Israel," but "all the Israelites went down to the Philistines to sharpen every man his share, and his coulter, and his axe, and his mattock, yet they had a file for the mattocks, and for the forks, and for the axes, and to sharpen the goads." Solomon had to send to Tyre for Hiram, "a widow's son of the tribe of Naphtali," who was "cunning to work all works in brass," to execute the masterpieces of the Temple, the enumeration of which in the seventh chapter of the first book of Kings throws much light upon the skill of that renowned artificer and his workmen, and their mode of working. We read of the articles which were of bright brass being cast "in the clay-ground, between Succoth and Zarthan." The metallurgical references in the Bible are frequent, indicating a general knowledge of the principles of refining ores as well as of working up the six then known metals, gold, silver, copper, lead, tin, and iron. Job speaks of nearly all these metals. "Surely," he says, "there is a mine for silver and a place for gold, which men refine;" then he mentions copper as "molten out of the stone;" and iron as being "taken out of the earth." Those who imagine that iron bedsteads are a modern invention need only be referred to the statement in the third chapter of Deuteronomy respecting Og, king of Bashan, who "remained of the remnant of giants." "Behold, his bedstead was a bedstead of iron," says the chronicler. We also have allusions to the various operations in connection with the making and dyeing of fabrics, and the manufacture of pottery. Jeremiah says, "Then I went down to the potter's house, and behold he wrought a work on the wheel. And the vessel that he made of clay was marred in the hand of the potter, so he made it another vessel as seemed good to the potter to make it."

Meanwhile, invention was developing at a more rapid rate in the countries whose conquering arms had opened the way for greater fame, and provided their citizens with more abundant opportunities for the exercise of higher intelligence. For a time the splendours of the ancient empires assisted the work of invention, but the luxury which led to their fall crippled the onward movement, and it was not until the Greeks absorbed what was best in the civilisations of the countries they conquered, and began to occupy themselves in improving the arts and manufactures, that the inventor got full play for the employment of his gifts. Then, side by side with the growth of that Hellenic art which reached its highest point in the sculptures of Phidias, there was a not less important expansion of effort and power in the direction of the mechanical arts. In the poetic literature no less than in the historic pages of ancient Greece, we find an abundance of proof of this remarkable activity. In the shield of Achilles, mentioned by Homer, we find in its combination of metals and its various bas-reliefs a knowledge of the metallurgic arts greatly in advance of that of the races which had been vanquished.

Bit by bit we get at the time when invention in its more modern meaning receives a most powerful impetus from the genius of Archimedes, who seems to have been one of those born inventors, with a universal talent for mechanical pursuits. Reading of his adaptation of the crank and pulley, his employment of the lever, with which he boasted he could move the world, his invention of the screw—one of the principal motors of our own time—his catapults and burning-glasses, his balistæ, and his famous galley of Hiero, we cannot wonder that, in those ancient times when genius of all kinds seemed to meet with its appreciation, he should have been revered and honoured, and rewarded for the benefits he conferred upon the people.

For some centuries after the period of Archimedes, invention does not seem to have made very rapid strides. The arts developed, but the improvement in architecture, engineering, manufactures, pottery, metallurgy, and chemistry, though most marked, right away down to and beyond the Middle Ages, yet resulted in no first-class invention of equal importance to the principal inventions of Archimedes, or to those still greater inventions which were to give such an impetus to the mechanical activity of the eighteenth and nineteenth centuries. The alchemists, working in their own mystical field, helped on the discovery of new metals, of which seven only were known until the fifteenth century, for it was only in 1490 that antimony was found. Bismuth was discovered about the time of the Reformation; and zinc, the most important of the later metals, seems to have come into general use about the same time, although there is good ground for believing that it was slightly known to the ancients. After this the earth was tapped more persistently than ever in quest of new metals, and about the middle of the eighteenth century, platinum and nickel were found, and research has continued ever since, until now we have, instead of the seven of the ancient time, upwards of fifty metals.

The Middle Ages, in which a bellicose feudalism, curiously tempered by a spirit of chivalry and romance, fettered the intellectual speculation of the time, gave birth to two inventions which have had a wonderful effect upon the course of human progress. The invention of printing was one, the invention of gunpowder the other. The first has done more for civilisation than any discovery that was ever made; the second has at times seemed to turn the world back almost to a condition of barbarism.

It was not until the eighteenth century, however, that the mechanical inventor began to assume the master position in the work of advancement. Almost simultaneously with the discovery of the true power of steam, there arose a number of mechanicians who, by the introduction in quick succession of valuable improvements in the construction of machines, enabled that power to be utilised to the full extent. The force of steam had long been known, but without any real appreciation of the degree to which it could be applied. The alchemists were familiar enough with the processes of evaporation and condensation, but did not look for their employment beyond the limited boundaries of their own investigations. In the seventeenth century attempts were made to employ steam for the purposes of machinery to a small extent, but the experimenters being ignorant of the true principles of the action of this force, and having no ambition to serve but that of curiosity, did not get very far on the way towards the practical utilisation of steam-power. The eighteenth century saw the problem solved. A student of chemical science with patient application worked out the principles of latent heat; and a student of mechanics, by careful experiment, arrived at a knowledge of the expansive force of caloric, and the idea of the steam-engine was discovered.

And as this mighty force was spreading itself over the face of the universe, now urging great ships across the ocean, now propelling the railway train over the length and breadth of every land, now moving the looms and spindles of thousands of factories engaged in the production of beautiful fabrics, now raising the water from deluged mines, or stirring the ponderous steam-hammer to its thunder-evoking power, there was another power, which had long been slumbering in half-revealed strength, upon which the ingenuity of man was being exerted with wondrous success. This was the power of electricity, which has taught man how to transmit his thoughts with their own velocity from world to world, how to turn night into day, and how eventually to excel even steam itself in strength and universality of application.

These are some of the leading discoveries with which the inventors of modern days have enriched the world. But in every department of science, art, and mechanics, the progress has been greater within the last hundred and fifty years than in all the thousands of years which previously passed. A hundred and fifty years ago there was no steam-engine, no spinning-jenny, no power-loom; and at the commencement of the nineteenth century there was no locomotive, no gas-light, no electric telegraph, no steam-printing press; to-day we have them all, and many more leading inventions.

And as the inventor still continues his patient work of developing the various forces of nature, and affiliating them to the uses of man, the coming time is rich with the promise of inventions which shall have their stories of magic and romance for future ages, stories as full of charm as the stories of wonder which have sufficed for the subject of the present volume.

CHAPTER II.

DREAMERS OF STRANGE DREAMS.

The Alchemists and their Objects—Their Failures and Discoveries—The Metals and their Star Affinities—The Philosopher's Stone—Count Bernard of Treviso—"Gibberish"—A Mystic Parable—The Poet of Alchemy—Moses a Reputed Alchemist—Hermes Trismegistus—His Thirteen Propositions—Egyptian and Arabian Alchemists—The Alchemical Philosophers of the Middle Ages—Paracelsus—Raymond Lully and his Romantic Adventures—His Residence in England and Transmutations in the Tower—His Tragic Death—Chaucer and the Alchemists—Faust's Alchemical Speculations—A Patent for Converting Copper into Gold and Silver—Martyrs of Alchemy—Alchemists of the Nineteenth Century—The Last Straw—Modern Men of Science on the Mystic Theories.

ONCE upon a time, before knowledge, invention, and experience had taught them better, some even of the most learned dreamed, plotted, and laboured after objects which were completely beyond the reach of human effort. The astrologer read in the stars a controlling influence over the actions and destinies of man; the magician assumed the power of arresting or diverting the laws of Nature; and the alchemist, working in the mysterious and then comparatively unknown field of chemistry, obtained such marvellous results that it was not surprising—living, as he did, in an age of credulity and superstition—he should have conceived the idea of ultimately discovering the means of defying death and securing the control of unlimited riches.

The alchemists were inventors whose hopes were based on illusion, whose objects were mainly selfish, whose achievements belonged to the realm of romance; still, chimerical as were their ideas, they laboured with singular skill and industry, and, in their search after the unattainable, stumbled upon many scientific facts which had previously lain hidden from the knowledge of man. If they failed to find the philosopher's stone and to transmute the baser metals into gold, they brought into vogue the natural processes of distillation, sublimation, filtration, and crystallisation, and invented the retort, the alembic, the crucible, the water bath, the sand bath, and many other things which have proved of great utility to the world. If they were unable to discover the substance which was to give them perennial youth and health, they brought to light, in the course of their experiments, much that was of benefit to medical science.

Astrology, magic, and alchemy formed a wondrous trinity, touching each other at many points, and never wholly separating. All metals were held to be mutually convertible, and the seven known metals—gold, silver, quicksilver, copper, iron, tin, and lead—were supposed to be in direct affinity with the seven planets after which the alchemists called them—Sol, Luna, Mercury, Venus, Mars, Jupiter, and Saturn. It was supposed that each metal was a compound of sulphur and mercury in different proportions and in different degrees of purity, and that any one metal was capable of being transformed into any other, by adding what was deficient or taking away what was superfluous in its composition. It was the philosopher's stone that was to work this marvel, the stone, however, being conceived to be in the nature of a powder or a fluid, as may be gathered from the description of one of the alchemists, who says:—"Our stone is nothing but an odeneous spirit and a living water (which we have also called dry water), purified by a natural proportion, and united in such a way that it can in nowise be absent from itself."

Then there was the red powder which was to convert all baser metals into gold; and the white tincture which was to turn them into silver; but, unfortunately, neither the one nor the other was ever discovered. The alchemist, however, chose "Nil desperandum" for his motto, and often imagined himself so near success as to think it advisable to write down in enigmatical terms understood only by himself directions for the making of the powders. An air of the profoundest mystery and secrecy was preserved in regard to their operations, and some of them endured much peril and hardship rather than disclose their discoveries.

Count Bernard of Treviso, who lived in the fifteenth century, when the alchemy craze may be considered to have been about at its height, has described the nature of his studies in considerable detail. From his account we get something of a notion of the operations of his predecessors. He and a monk worked together for twelve or fifteen years, experimenting in search of the philosopher's stone. He studied Rhazes and Geber. The latter (from whom the word "gibberish" is derived) was not more intelligible to the Count than he had been to others, for it took him several years to read Geber's book, which cost him over two thousand crowns. For three years Count Bernard read Archelaus, and after that Rupecissa, whose instructions he and the monk followed, working with alcohol, which they rectified more than thirty times, until no glass that they could find was strong enough to hold it.

"After living thus twelve or fifteen years," wrote the Count, "finding nothing: after making experiments to dissolve, congeal, and sublime common salt, sal-ammoniac, all kinds of alum and copperas, marchasites (all stones containing metal of any kind were called thus), blood, all species of animal or vegetable secretion, I proceeded by every means, distillation, sublimation, circulation, by separation of the elements by alembic and athanor (this was a close inner furnace, which was kept carefully at the same temperature. It was heated not with a vulgar fuel, but with a certain matter about which every philosopher made a great secret. It produced a fire not liable to be extinguished. It was called philosopher's fire, and generally produced by animal matter), by putrefaction, by decoction, and by an infinitude of other modes. All these operations I pursued for twelve years, by which time I was thirty-eight years old. I had spent besides upon the extraction of mercury from herbs and animals about six thousand crowns."

The chief value of Count Bernard's contributions to the literature of alchemy lies in the fact that in the form of a parable he has professed to reveal the great secret of the philosopher's stone. He says: "I one day was wandering in the fields, and I came upon a fair fountain, surrounded with palisades. None except the king of the country has the right to approach and bathe therein. The king goes into it by himself; none may accompany him. So soon as he has entered the enclosure, he takes off his robe of cloth of fine beaten gold, and hands it to his head man, who is named Saturn. Saturn takes it, and keeps it for forty days. The king then takes off his under-garment of fine black velvet, and hands it to his second man, who is Jupiter, who keeps it for twenty long days. Then Jupiter, at the command of the king, gives it to the Moon, who is his third attendant, beautiful and resplendent; she keeps it twenty days also. The king is now in his shirt—pure and white like snow. Then he takes off his shirt, and gives it to Mars, who keeps it forty days. After that, Mars hands it to the Sun. It has become yellow and not clear. The Sun keeps it twenty days, when it becomes beautiful and red. I met with an old priest, who told me these things. I said to him, 'Of what use is all this?' He replied, 'God made both one and ten, a hundred and a thousand, and multiplied the whole ten times.' I said, 'I do not understand this!' He answered, 'I will tell thee no more, for I am weary.' I then perceived that he was tired. I, too, felt an inclination to go to sleep!" As a sample of the mystical jargon used by these misguided, but often sincere, dabblers in the unknown, Count Bernard of Treviso's parable is not without interest, though it fails to convey much real information.

The alchemists were as silent as the grave in regard to the matter or substances which formed their first foundation; this was religiously guarded as the secret of secrets, never to be divulged, except it was to one in whom perfect grace, piety, prudence, and virtue existed, and then only accompanied by "a most secret dreadful oath." The poet of alchemy, Thomas Norton, of Bristol, who lived in the time of Henry the Eighth, says that—

"Amongst millions millions of mankinde
Scarcelie seven men may this science finde."

The same writer, who held the wonderful science of "secret philosophie" in reverential awe, has a notable reference to one of the more prominent professors of the art, Raymond Lully, who was supposed to have left behind him the great secret emblematically disclosed in seven images, which he set up "in a city of Catilony." Norton says:

> "Three were good silver, in shape like ladies bright,
> Everie each of four were gold, and like a knight;
> In borders of their clothing letters did appear,
> Signifying in sentences, as it showeth here:
> 1. 'Of old hobnails,' said one, 'I was yre;
> Now I am good silver, as good as ye desire.'
> 2. 'I was,' said another, 'iron, set from the mine;
> But now I am gold, pure, perfect, and fine.'
> 3. 'Whilome was I copper, of an old red pann;
> Now I am good silver, and the third woman.'
> 4. The fourth said, 'I was copper, grown in the filthy place,
> Now am I perfect, God-made by God's grace.'
> 5. The fifth said, 'I was silver, perfect thro' fire;
> Now I am perfect gold, excellent, better than the prime.'
> 6. 'I was a pipe of lead nigh two hundred year;
> And now, to all men, good silver I appeare.'
> 7. The seventh said, 'I leade, am gould made for the maistrie,
> But trewly my fellows are nearer thereto than I.
> Covertize and cunning, have discorde by kinde,
> Who lucre coveteth this science shall not finde.'"

Tracing the so-called science back to its infancy, we find ourselves in the remote region of tradition, It was believed that the secrets of alchemy were imparted by the angels to the most worthy of the antediluvians, but that the Deluge left not a wrack behind of the great mystery. Most of the alchemists relied upon the story of the golden calf in the 32nd chapter of Exodus to prove that Moses was an adept, and could make or unmake gold at pleasure. The search after the secret that the Flood was supposed to have swept away with it was afterwards taken up by the ancient Egyptians, the first name that occurs in connection with it being that of Hermes Trismegistus, the emerald tablet of whose tomb (said to have been found by Alexander the Great, but really belonging to a later date) contained the thirteen propositions which were supposed to embody in some symbolic way the principles of alchemy. For centuries these propositions were studied by the alchemists, but neither time nor learning solved the riddle for them. To some extent they taught them the art of mystification, but nothing beyond. The thirteen propositions were:

"I. I speak not fiction, but what is certain and most true.

"II. What is below is like that which is above, and what is above is like that which is below, for performing the miracle of one thing.

"III. And as all things were produced from one, by the mediation of one, so all things were produced from this one thing by adaptation.

"IV. Its father is the sun, its mother was the moon, the wind carried it in its belly, its nurse is the earth.

"V. It is the cause of all perfection throughout the whole world.

"VI. Its power is perfect if it be changed into the earth.

"VII. Separate the earth from the fire, the subtle from the gross, gently and with judgment.

"VIII. It ascends from earth to heaven, and descends again to earth. Thus you will possess the glory of the whole world, and all obscurity will fly away from you.

"IX. This thing is the fortitude of all fortitude, because it overcomes all subtile things and penetrates every solid thing.

"X. Thus were all things created.

"XI. Hence proceed wonderful adaptations, which are produced in this way.

"XII. Therefore am I called Hermes Trismegistus, possessing the three parts of the philosophy of the whole world.

"XIII. That I had to say concerning the operation of the sun is completed."

How deeply this mysterious communication became impressed upon the minds of the followers of alchemy is sufficiently indicated by the fact that the Arabian physicians, who in the early centuries of the Christian era took up the doctrine of transmutation, and elevated it into a science, used to describe their first attempts to bring about the fixation of mercury as trying to catch the "flying bird of Hermes."

Although the Arabs overran Egypt with fire and slaughter, destroying the multitudinous evidences of the learning of the conquered races, they were not long in building up a reputation for knowledge surpassing that of the people they had conquered. But it was not until the eighth century that any illustrious Arabian stood forth as the exponent of the principles of alchemy, when Geber, to whom we have already referred, gave, or pretended to give, a full history of the science. Previous to that time, Synesius, Bishop of Ptolemais, had attracted some notice by his experiments in alchemy; and, coming down to the tenth century, we find the name of Morien prominent among the seekers after the universal elixir. Artephius, who lived in the twelfth century, was the most renowned alchemist of his day, and was commonly believed to possess the secret of Hermes. He has been credited with the invention of soap, and was the promoter of a new interpretation of Jacob's ladder, or Homer's chain. Albert Groot, known as Albertus Magnus, who died in 1280, revived Geber's theory of parallelism between the metals and the planets, and gained much distinction for himself. St. Thomas Aquinas, Pope John XXII., Alphonso X. of Leon and Castile, and many other illustrious personages, occupied themselves with alchemy; and Paracelsus, whose mystic history has afforded Browning so fine a poetic theme, brought his strong individuality to bear with striking effect upon alchemical philosophy. Paracelsus had nothing but contempt for mere seekers of gold. "Away with those false disciples," he says, "who hold that this divine science which they dishonour and prostitute has no other end but that of making gold and silver. True alchemy has but one aim and object, to extract the quintessence of things, and to prepare arcana, tinctures, and elixirs, which may restore to man the health and soundness he has lost." As a worker in the field of medical chemistry, Paracelsus was one of the foremost men of his time.

Modern therapeutics owes much to the opium and mercury of this gifted philosopher, as well as to the laudanum of his disciple Quercetan, physician to Henry IV. The Middle Ages, indeed, produced many celebrated chemists, who were led by their taste for alchemic theories to important discoveries. Glauber, Kunckel, Glaser, Roger Bacon, Arnauld-de-Villeneuve, Flamel, all contributed more or less to the advancement of chemical science while pursuing their quest of the philosopher's stone.

The alchemist with the most romantic history, perhaps, was Raymond Lully, who was born at Majorca, of a noble family, in 1234. He grew up to be an accomplished and handsome cavalier, and James II. of Aragon showed him much favour, appointing him seneschal of the isles, and grand provost of the palace. Rich in his own right, and made richer still by a wealthy marriage, Raymond for a long time lived a life of reckless dissipation. A strange adventure with a beautiful woman of the

Court, Donna Ambrosia Eleanora di Castello, however, brought about a sudden change in his mode of life, and he divided his property and gave himself up to study and meditation. He had a vision, twice repeated, in which he imagined he beheld the Saviour, who commanded Raymond to follow him thenceforth. Lully retired to a hut on Mount Aranda, near his estate, and lived there the life of a recluse for the next six years, studying Arabic and preparing himself for the conversion of the infidels. Setting forth on his wanderings, accompanied by a Mohammedan servant, he had not gone far before the servant attempted to murder him, wounding him so seriously that for a time he was compelled to return to his solitude.

Setting out on his travels again, he visited Paris, and made the acquaintance of Arnauld-de-Villeneuve, the most noted alchemist of his time, and enrolled himself as one of Arnauld's disciples. While with him he invented a new mode of teaching philosophy and the sciences, afterwards called the Lullian art. Subsequently, Raymond visited Rome, Geneva, and Genoa; then he sailed to Tunis, and made himself so much feared and hated by the Mohammedan doctors that he was arrested and condemned to death, but on the intercession of a learned Arabian, who pleaded that it would be an injustice to kill so great a man, his life was spared on condition that he left Tunis and never returned.

Lully went back to Genoa, and now more than ever impressed by the desire to convert the infidels, tried to get up a crusade. He visited Naples, Milan, Paris, and Algiers, making many converts at the last-named place. Here it was that he was thrown into prison, a padlock being placed upon his mouth to prevent him from speaking. After forty days he was bastinadoed, and expelled the city. He escaped to a vessel bound for Genoa, but being shipwrecked in sight of Pisa, suffered great hurt, resulting in a violent illness. On his recovery he proceeded to Vienna, and while there was honoured with letters from Edward II., King of England, and Robert Bruce, King of Scotland, asking him to visit them; but it was more to please Cremer, Abbot of Westminster, whom he had met in his travels, than to seek favour with the kings, that he ultimately determined to go to England. Cremer and Lully journeyed together, and the abbot lodged his friend in Westminster Abbey. It was under the promise of obtaining assistance from Edward, in sending out an army against the infidels, that Cremer was able to prevail upon Raymond to accompany him, though Cremer's real object was to discover the alchemist's secret of transmutation. The abbot plied the philosopher craftily, and at length persuaded him to part with his secret on the express condition that the gold to be made should not be used for the luxuries of the Court or upon a war with any Christian king, and that Edward should himself lead the promised crusade. The alchemic powder was gradually perfected, and Lully was presented to his Majesty, who readily consented to all that was desired, under the impression that he was about to be put into the way of boundless riches. The alchemist had rooms allotted to him in the Tower, and there, according to his own story, he transmuted fifty thousand pounds' weight of quicksilver, lead, and tin, into pure gold, which was coined at the Mint into six millions of nobles, each worth about £3 sterling of our present currency. Whether Edward benefited or not by the operations of Lully, he did not think proper to fulfil his part of the bargain. No crusade was organised; instead, the Christian alchemist found himself treated as a prisoner, and, after presaging all kinds of evil and misfortune for the monarch by whom he had been deceived, he ultimately made his escape, left England, and proceeded to Egypt. Thence he went to Jerusalem, and afterwards to Tunis, where the Mohammedans fell upon him and stoned him. Still just alive, he was discovered by some Genoese merchants, who carried him on board their ship and set sail with him. He lingered until they came within sight of Majorca, and died on the 26th of March, 1315, at the age of eighty-one, being afterwards buried with great honour in the family chapel of St. Ulmo.

Many antiquarian collections contain coins which are said to have been made from the gold transmuted by Lully in the Tower; and it is stated that when the cloister which he occupied at Westminster was removed, some of the alchemic powder was discovered by the workmen, who made themselves rich thereby. But be this as it may, some of Lully's contributions to science possessed genuine value. The preparation of sweet nitre was one of his discoveries.

In the fourteenth century a belief in alchemy was generally prevalent in England. In 1329, Edward III. forwarded writs to the sheriffs stating that "John le Rous and Master William de Dalby, by the art of alchemy, knew how to make, and had made, and were making silver; and because by making that metal, if it really could be made, much profit might come to the King and to the kingdom. Thomas

Cary had been appointed to bring them up safely to the King, together with the instruments used in their art, conducting them honourably if they would come; if not, using force." Monarchs in those days took a hopeful interest in the pursuits of the alchemists, and frequently used their kingly power, as in this instance and that of Raymond Lully, to extort, by means fair or foul, the hermetical secrets from those who professed to hold them.

The literature of the period abounds in allusions to alchemists, true and false. Gower accepted "alconomie" as a true science. Chaucer, on the other hand, while sympathising with those who honestly believed in the theories of transmutation, had not the least faith in them himself, and had nothing but contempt for the pretenders who explained one mystery by another more inscrutable, and, when evasion would serve them no longer, proclaimed that they were forbidden by the highest authority to disclose the mystery. In his "Canon's Yeoman's Tale," the poet has satirised the alchemists with all the bitterness at his command, making the Yeoman describe, with infinite humour, the methods of the mystic philosophers—their labours at their fires, their inhalation of the mercurial fumes until their faces were the colour of lead, their beggarly condition, and their unfaltering hope of success amidst the utmost wretchedness—finishing with the sage advice:

> "Than, thus conclude I, sin that God of heven
> Ne wol not that the philosophies neven [1]
> How that a man shal come unto this ston,
> I rede [2] as for the best to let it gon."

Chaucer's portraits of the two alchemist canons

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[1] name.

[2] advise.

(the sincere believer and the impostor) are forcibly drawn. The one is the earnest projector, who, under the spell of firm conviction, continues his experiments with unwavering faith through rags and poverty, no amount of failure robbing him of his hope. Even when his crucible bursts, spreading destruction on all sides, he takes heart amidst the disaster, chides his workmen for their rancorous blaming of each other, and bids them not despond.

> "What? quod my lord, ther n'is no more to don,
> Of these perils I wol beware eftsone;[1]
> I am right siker[2] that the pot was crased,[3]
> Be as be may, be ye no thing amased
> As usage is let swepe the flore as swithe;[4]
> Plucke up your hertes and be glad and blithe."

The other canon is the cheat and impostor, the pretender who, knowing how easily the ignorant can be duped into supplying money for the prosecution of alchemical projects, fools his victims to the top of their bent. There were many projectors of this type in Chaucer's time, some of whom, by resorting to easy tricks and devices, contrived to cajole their neighbours into the belief that they possessed the secret of transmutation.

Ben Jonson's Subtle of the *Alchemist* is of the same false pattern, a knave of the first order; while Face, his yeoman and abettor, is not a whit more honest. The object of Jonson's comedy is the same as that of Chaucer's "Canon's Yeoman's Tale," the exposure of alchemistical sophistry and illusion, towards which they contributed in no small degree.

In the legendary lore of Germany, there are many strange and wondrous pictures gathered from the mystic shadowland of alchemy. Goethe's *Faust* (of which Marlowe's *Dr. Faustus* is the English prototype) indulges in day-dreams and speculations similar to those of the alchemists, and it is in the moment when despair and weariness have come over him in his search after the unattainable that Mephistopheles succeeds in getting him into his power. His despairing cry is:

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[1] presently. [2] sure. [3] cracked. [4] quickly.

> " Everything fails me, everything !
> These instruments: do they not all
> Mock me ? Lathe, cylinder, and ring,
> And cog and wheel, in vain I call
> On you for aid, ye kings of science !
> I stand before the guarded door
> Of Nature ; but it bids defiance
> To latch or ward ; in vain I prove
> Your powers; the strong bolts will not move.
> Mysterious, in the blaze of day,
> Nature pursues her tranquil way ;
> The veil she wears, if hand profane
> Should seek to raise, it seeks in vain."

Still, although in the year 1404 it was made an act of felony to multiply gold or silver, the delusion of alchemy survived here and there for a century or two later. Sir Giles Mompesson and Francis Michel (the originals of the Sir Giles Overreach and Justice Greedy of Massinger's *New Way to Pay Old Debts*) applied for a patent in 1618 for a new alchemistical way of making gold and silver or lace with copper; and Lord Bacon, who was then Lord Chancellor, the Lord Chief Justice, and the Attorney General, certified that it was " fit and convenient, and that it would redound to the king's profit at least £10,000 a year."

Amongst the many disciples of alchemy who suffered for their faith may be mentioned De Lisle, who died in the Bastille of the wounds inflicted on him to extort his secret; and, in England, Dr. Price, who, rather than face the ordeal of a public trial of his powder of transmutation, committed suicide.

There have been alchemists even in this century. Peter Woulfe, who lived in Barnard's Inn, Holborn, up to the year 1805, was a professor of the Hermetic mystery; and about the same period there was a London editor who avowed himself learned in the science, and professed to believe that if he could keep his materials digested in a lamp furnace for seven years, he would solve the secret of transmutation. Unfortunately, the lamp went out when it had been burning six years, eleven months, and a few days. In 1828 there was an alchemist named Kellerman, living at the village of Lilley, near Hitchin, who asserted he had discovered the philosopher's stone, and also the universal solvent. Sir Richard Phillips visited him, and has left on record the statement that Kellerman had made Lord Liverpool the offer that if he would introduce him to the King he would reveal his discovery to his Majesty. Lord Liverpool declined to be a party to the mystic ceremony, so there the matter dropped, Kellerman resolving that if the King would not accept his secret it should die with its possessor. It is said that Kellerman employed eight assistants in his laboratory.

So recently as 1842, a person advertised in the *Athenæum* offering, for a fee of two hundred guineas, to furnish a "philosophical student, or other pupil," with "a proper quantity of the requisite mercurial matter (prepared by a professor of long experience and research in both the ancient and modern chemical schools) wherewith to operate for the profitable application of the Hermetic science, as a source of wealth to the fortunate operator in this mystical branch of metallurgic chemistry, successfully practised by Flamel, Lully, and other adepto-chemical philosophers of the Middle Ages." This was the last straw. When the grand science of the ancient philosophers came to be advertised like a quack pill, and the secret over which innumerable lives and fortunes had been spent in vain, came to be offered in a public journal to any one who liked to pay for it, it was time that it should be finally removed from the place it had so long held in the list of the serious sciences.

Alchemy, undertaken by many great and good men as a true science, which was to reveal to them the seed or germinating principle of metals, was brought into ridicule by the charlatanism of false professors, who traded upon its mysticism for purposes of imposture; and under the influences of a broadening civilisation, the dreamland through which the philosopher's stone had for centuries glimmered like a will-o'-the-wisp gradually faded into cold reality; and, though leaving little behind but memories and legends in regard to its masters, yielding tangible results to the safer science which keeps within the limits of the attainable. In their theories concerning the making of gold, however, the alchemists were not so far away from the possible as is popularly deemed. Dumas, the great French chemist, was of opinion that a solution might be found in the doctrine of isomerism; and Sir Humphry Davy would not say that the alchemists must be wrong.

CHAPTER III.

MARTYRS OF INVENTION.

Suffering and Sacrifice of Early Inventors—The Perils attending the Display of Superior Skill in Ancient Times—The Emperor and the Crystal Vase—Execution of the Inventor of an Automaton—The Inventors of Printing Denounced by the Priests and the Guild of Writers—William Ged and the Art of Stereotyping—A Double Martyrdom—Henry Cort and the Puddling Furnace—His Ruin and Death—Dr. Roebuck and James Watt—Disasters at Carron—The Change from Manual to Steam-worked Machines—Alarm of the People—Machinery Riots—William Lee and the Stocking-loom—Queen Elizabeth refuses him a Patent—His Poverty and Death Abroad—The Story of John Lombe—John Kay and the Fly Shuttle—He is pursued from Place to Place—Dies in Destitution—Hargreaves and the Spinning-jenny—Crompton and the Mule—His Fiddle proves a Good Friend—Is Compelled to hide his Machine—Gets Robbed of his Secret—"They Shall not have this too"—Parliament is Petitioned on his Behalf—Disappointment, Losses, and Death.

INVENTION has had its martyrs no less than religion. Every step of the path of mechanical improvement is marked by signs of suffering and sacrifice. To the inventor all ages have been Dark Ages until the fruits of his genius have been ready for the reaping of those who have not had the labour and pain of sowing. The success of an invention has depended so much upon the profit it would yield to the world in general, that the man in whose brain the thought has been conceived, whose mind has patiently wrought out the problem, has only too often been forgotten or neglected in the confusion of ultimate triumph. A mere enumeration of the recorded instances of the martyrdom of inventors would be a task of enormous magnitude, and for our present purpose it must suffice if we confine our attention chiefly to those who, in their connection with the great industries of modern times, have linked their individuality for ever with the improvements by which they revolutionised the manufacturing arts.

In ancient times it was a perilous thing to be an inventor; the man who could perform a scientific or mechanical feat, which was beyond the knowledge of his neighbours, was regarded as dangerous. It is related of one of the Roman Emperors, that on a certain occasion when a subject exhibited to the Court a large crystal vase which would not break when dashed to the ground, the monarch came to the conclusion that such a person was too clever to be at large, and had the poor wretch led off to immediate execution. Alex of Provence fared no better in the seventeenth century. He invented an automaton skeleton, placed it in his window, put a guitar in its hand, and set it playing, so that it could be heard and seen by all who passed. It was at once condemned as an instrument of magic and witchcraft, and poor Alex and his invention were burnt together, by command of the Parliament. The elder Droz, for making an automaton writing-boy, was seized upon by the officers of the Spanish Inquisition, and but just escaped with his life.

Gutenberg and Fust, the inventors of printing, excited the jealousy and wrath of the priests and the guild of writers, and suffered grievously from persecution, as well as from legal entanglements of their own creation. It was Gutenberg who first discovered and practised the art of printing with movable types, in the perfecting of which he spent the whole of a large private fortune. Fust, his partner and co-worker, made a similar sacrifice, and although they had the honour of issuing the first printed books from their press at Mayence, they lost almost everything else, wealth, position, and the favour of princes, by their invention, and, worse than all, impoverished themselves still further by going to law one with the other over the cost of their printing experiments.

A double martyrdom luridly illuminates the invention of stereotyping. In 1725, William Ged, a goldsmith of Edinburgh, devised a process for casting whole pages of type, but his endeavours to apply his invention met with so much bitter prejudice and opposition on the part of the compositors, who fancied they saw in this new notion an interference with their vested interests, that he was obliged to have recourse to secrecy in order to obtain for it a practical test. Having exhausted his own means, Ged was assisted by the subscriptions of a few friends, and by the aid thus afforded and the help of his son, James, who had been apprenticed to a printer, the first known experiment in actual stereotyping was made. James's master consented to his apprentice setting up the *formes* to be stereotyped in the night-time, after the other compositors had left off work, and in this way there came to be printed from stereotype plates made by Ged, in 1739, an edition of Sallust, which attracted much attention at the time as a curiosity in printing, but did not help the fortunes of the inventor in any way, the disappointed and badly used Scotsman dying some years afterwards in great poverty. James Ged subsequently tried hard to revive his father's invention; but "the trade" declined to encourage him, and, defeated and frustrated at every point, he emigrated to Jamaica, and there died, friendless and poor.

Henry Cort, of Gosport, was another martyr. He invented the puddling furnace, and spent a fortune of £20,000 in bringing his processes into use. At one time it seemed as if he had found the way to riches by his invention; his firm was specially employed in connection with the Naval Dockyard, and the chief iron-masters of the country contracted to pay him ten shillings a ton for the use of his discoveries. All might have been well but for the defalcations of Adam Jellicoe, his partner, which led to the intervention of the Treasurer of the Navy at this point, who seized Cort's patents, confiscated his freeholds at Fontley, Farnham, and Gosport, valued at £39,000, and handed them and the control of the business over to the son of a prominent personage in the Navy Office. The secret passages of these transactions will never be known, for when inquiry came to be made years afterwards it was found that all documentary evidence touching the matter had been destroyed. Cort died a ruined man, with nothing but beggary to bequeath to his nine children. A pension of £19 a year to his daughters was all the recognition the State bestowed, beyond the wholesale confiscation alluded to, upon the man whose inventions had enriched his country by scores of millions of pounds. A few ironmasters subscribed a small sum to Cort's family, which served to keep them from starvation. What this sum was we do not know, but an arithmetician who *did* know, calculated the amount to be equivalent to "a twentieth part of a farthing in the pound upon the profit they had made of Mr. Cort's inventions."

Another victim whose genius was devoted to experiments in the iron trade was Dr. John Roebuck, the grandfather of the late Mr. J. A. Roebuck, M.P. He was a native of Sheffield, the town which his grandson so long represented in the House of Commons, but, having settled in Birmingham as a doctor, gave himself up to the study of practical chemistry. He discovered an improved method of refining the precious metals, and also a cheaper process of obtaining sulphuric acid, which was in great demand for manufacturing purposes. He now abandoned his profession, and went to Scotland, where, at Carron, in 1759, he opened the first ironworks that were ever established in that country. Later on, he speculated in coal mines near Edinburgh, which did not turn out well, the mines being flooded with water; then, making the acquaintance of James Watt, who was at the time busy with his steam-engine, he arranged a partnership with him, finding the capital for their joint operations; but before the mines could be drained and the steam-engine completed, the inventor of the new metallurgic processes was involved in ruin, and died, in 1794, a martyr to his enterprises.

It is, however, in connection with the mechanical operations involved in the production of textile fabrics, that inventors have met with the greatest ingratitude from those whom they have benefited, and have suffered the severest hardships. Capitalists have often been ready enough to welcome the inventions of the workers in this field of rapid progress, if for nothing else than for the sake of the profitable account to which such inventions might be turned for themselves; but in the critical days when the change was being effected from hand-labour to machinery worked by steam, the inventors had all the operative classes against them, for it was imagined that the more manual labour was dispensed with the less employment would there be for the working people? This was a kind of argument that, to those who were unable to conceive the increased demand that would result from the cheapening of fabrics, seemed unanswerable. It was the hatred of the people, perhaps, even more than the greed and duplicity of the capitalists, that made the task of the early heroes of the factory so full of embarrassment and difficulty. To the popular mind, the introduction of machinery meant the enriching of the few to the impoverishing of the many, and riot and tumult was the reply of the masses to every great mechanical improvement, until the adjusting influence of time and experience proved to the alarmists that their fears had been groundless, and that far from having had their lot made worse by the accession of the new power, their individual earnings had been increased, work had become more plentiful, and the general prosperity of the country had been greatly bettered. Thus the condition of things has been completely altered; men of science have no longer to contend with the serious drawbacks which hampered them in the past; the interests of the mechanical genius and the worker have ceased to be antagonistic; and inventors who suffer martyrdom now will do so from very different causes from those which were in operation in the early portion of the century, and before.

One of the first names that meets us in the annals of English mechanical enterprise is that of William Lee, the inventor of the stocking-loom. Lee was curate of Calverton, in Nottinghamshire, and made his first loom in 1589. He brought it up to London, and, having set it up in his lodgings in Bunhill Fields, prevailed upon Queen Elizabeth to do

Queen Elizabeth's Visit to William Lee.

him the honour of inspecting it. Her Majesty was accompanied by Lord Hunsdon, who, the tradition is, urged her to give the young clergyman a patent for his invention. The Queen is reported to have made reply: "My lord, I have too much love for my poor people, who obtain their bread by the employment of knitting, to give my money to forward an invention that will tend to their ruin by depriving them of employment, and thus make them beggars. Had Mr. Lee made a machine that would have made *silk* stockings I should, I think, have been somewhat justified in granting him a patent for that monopoly, which would have affected only a small number of my subjects." If the Queen really did make this elaborate and wordy answer to Lee's appeal, it is clear she would have been on the side of the Luddites if she had lived in the nineteenth century. The King of France (Henry IV.), however, lent Lee his sympathy, if Elizabeth would not, and invited him to bring his invention to Normandy; but troubles came upon the inventor after the assassination of the King: his stocking-loom was cast to the winds, and, as appears from a petition of frame-knitters, many years afterwards presented to Cromwell, "his affairs fell into disorder, which plunged him into dejection and speedily caused his death."

A strange story is told of John Lombe, who was the first to introduce the Italian method of silk-throwing into England. No one in this country knew this system, and the King of Sardinia, in whose dominions the silk manufacture had reached the highest perfection, had made it death for any man to discover the invention, or attempt to carry it out of his kingdom. In spite of all this, John

Lombe (to use the words of a petition that came before Parliament at a later date) "resolved to venture his person for the benefit and advantage of his native country, and Sir Thomas (his half-brother, then a successful business man in London), was resolved to venture his money, and to furnish his brother with whatever sums should be necessary for executing so bold and so generous a design. His brother went, accordingly, over to Italy, and after a long stay and a great expense in that country, he found means to see this engine so often, and to pry into the nature of it so narrowly, that he made himself master of the whole invention, and of all the different parts and motions belonging to it." It was a perilous undertaking, but John Lombe succeeded in all that he had set himself to accomplish. He stayed several years in Piedmont, and might have remained longer had not the Italians surprised him in his secret investigations, and made immediate flight necessary. He reached London in 1716, he and his brother obtained a silk patent, and they set up a large factory near Derby at a total cost of £30,000, where for many years a prosperous business was carried on. The strangest part of the story remains to be told. Mr. Hutton, in his "History of Derby," says: "John Lombe had not pursued this lucrative commerce more than three or four years when the Italians, who felt the effects from their want of trade, determined his destruction, and hoped that that of his works would follow. An artful woman came over in the character of a friend, associated with the parties, and assisted in the business. She attempted to gain both the Italian workmen (two whom Lombe had brought over with him), and succeeded with one. By these two slow poison was supposed, and perhaps justly, to have been administered to John Lombe, who lingered two or three years in agony, and departed. The Italian ran away to his own country, and madam was interrogated, but nothing transpired, except what strengthened suspicion." John Lombe was only twenty-nine years of age at his death. Derby gave him a splendid funeral.

We now come to three great names amongst the men whose inventive skill built up the cotton industry of Lancashire, giving to that branch of commerce a series of improvements unparalleled in the entire history of manufactures. These men were John Kay, the inventor of the fly-shuttle; James Hargreaves, the introducer of the spinning-jenny; and Samuel Crompton, the originator of the mule. They were all men of the artisan class, uneducated and poor, but were endowed with natural faculties which enabled them to make a more enduring impression upon the world than anything that could have been done by the mere power of scholarship or wealth. Richard Arkwright was equally humble, and in his inventive successes in connection with the spinning of cotton equally famous; yet, having a more worldly and more practical mind than they, not only managed to escape the fate of the inventor-martyr, but won riches and the distinction of knighthood for himself.

John Kay was born at Walmersley, near Bury, on the 16th of July, 1704. He was the son of a woollen manufacturer, and was brought up to a knowledge of his father's trade. He took a deep interest in the various mechanical processes, and was struck with the primitive nature of the cloth loom, which had remained without improvement for more than five thousand years, the same slow and clumsy contrivances that had supplied Egypt with its mummy-cloth and India with its muslins being still in tedious operation. He set his wits to work to alter this state of things, and produced in quick succession a new system of reeds and the celebrated flying-shuttle, reducing, by these and other improvements, the labour of weaving by fully one-half. His inventions enabled a weaver to produce more than double the quantity of cloth that he had previously made, improved the quality, and greatly lessened the physical labour. Looking at these results by the light of our present knowledge of their importance, it is almost past belief that for his great services to a valuable industry Kay was regarded with the most obstinate hatred. Establishing himself at Colchester, he managed a woollen factory there until he was driven from the place by the hostility of the workpeople. He then went to Leeds, and set up as an engineer, but the Yorkshire clothiers treated him disgracefully. They did not so much object to use his shuttle as to pay him any royalty on his patent; and they formed themselves into a Shuttle Club for the purpose of combining to defy Kay, who was compelled to put the Court of Chancery in motion for his own protection. Nor did his troubles end here. The workpeople rose up in resentment against him, and forced him to close his machine shops. He then returned to his native place, and sought for favour amongst his old friends, but the popular hatred of his inventions followed him wherever he went; and he had hardly got settled in his home at Bury when the mob broke into the house, destroyed all his furniture and implements, and would, in all probability, have killed him into the bargain, had not a couple of friends conveyed him in a wool sheet to a place of safety. He dragged on a miserable existence for other ten years, now hoping, now despairing, but failed to meet with justice, reward, or encouragement anywhere. An application for assistance made on his behalf to the Society of Arts and Manufactures received no attention, and, worn out in body and means, he went to France to try his luck there. Misfortune still kept close at his heels, and, failing to find any remunerative occupation, he acted upon the advice of the English Ambassador at Paris, and returned to his native country with the view of establishing a claim to some reward from the Government. After much wearying and humiliating contention with officialism, he was told that the Government could do nothing for him, and betook himself in disgust once more to France, where he soon afterwards died in extreme poverty, attended by a faithful daughter who sought the refuge of a nunnery rather than linger in the destitution in which her ill-starred father had left her.

Hargreaves, who invented the spinning-jenny in 1767, was hardly less fortunate than Kay. By his invention he increased the spindle-power enormously; first substituting eight spindles for one, and afterwards eighty for eight. Such an increase of producing power filled the spinners with alarm, and, to escape the riots and disturbance which his jenny evoked, the poor inventor fled from Blackburn to Nottingham, where the Strutts took the machine off his hands, utilised it, and made their fortunes by it. As for Hargreaves, he survived for a time in want and distress, and then, unhonoured and unmourned, departed from a world which had always treated him with coldness and neglect.

But the great work of mechanical improvement went on in spite of all. As one leader fell, another took his place, and thus the battle was continued until the conquest was completed. Arkwright proved himself a clever adapter and contriver, and, if he possessed less of the inventor's power of originating than others who preceded and followed him, he was an adept at finding and bringing together links of mechanical connection, and in this way exerted as great an influence as any of his rivals in the promotion of the cotton industry. It was left to Samuel Crompton, however, to put the finishing touch of genius to the spinning machinery which Hargreaves and Arkwright had done so much to improve.

Crompton was the only son of a widow, who, in her own person, fulfilled the duties of mother, farmer, carder, spinner, and overseer of the poor. The Cromptons lived in an old mansion called "Hall-i' th' Wood" at Firwood, near Bolton, along with a sick and crippled relative, known as Uncle Alexander. As young Samuel grew up he was put to the loom, and worked there steadily day by day, with occasional relief at night, when he either went to an evening school at Bolton or remained at home to practise the fiddle, for which instrument he had a great liking. In time Samuel displayed a striking affection for his work. Its difficulties attracted him, and he evinced a strong desire to overcome them. Arkwright had undoubtedly produced a finer and harder thread than Hargreaves, a thread which could be used for warp as well as weft; but still the thread was too coarse, still it was always breaking, still the loom had to be stopped every minute or two while the broken ends were pieced together again. The young weaver fell a-wondering whether it was not possible to invent a spinning-machine that would make a yarn that would run without this continual falling to pieces, he began to neglect his fiddle in his leisure moments to try experiments in the night in the deserted rooms of the old hall in the wood. The more he experimented the more confident he became of his own skill, and all his spare money went in the purchase of materials for the construction of his first model. So much did he feel the want of funds, that he took an engagement as violinist at the Bolton Theatre, his earnings of eighteenpence a night proving a godsend to him in his difficulties. He sought no aid from any one, but continued his experiments in secret for a period of five years, at the end of which time his machine was perfected, and ready to undertake the work of spinning finer yarns than had ever been spun before.

During the time of the machinery riots he had taken his machine to pieces, and hidden it away "in a garret near the big clock in the old hall;" but now he brought it out again, and began to spin his first threads upon it. It soon became known that young Crompton had put into the market a finer yarn than any one else could produce, and orders crowded in upon him faster than he could execute them. All this pointed in the direction of fame and prosperity, and on the strength of it he bought himself a new silver watch, and took unto himself a wife from amongst the Lancashire "witches." Various means were resorted to of discovering Crompton's secret, but he fenced it round with all sorts of precautions, for he had firmly resolved to keep it to himself until such time as he could save money enough to take out a patent. Still, do what he would, the secret of his spinning machine leaked out, and Arkwright travelled sixty miles to have a look at the new "muslin wheel," as it was called.

When Crompton saw that it was impossible to keep his invention a secret any longer, he began to think of the best means of making a bargain with the public. He put himself in communication with the manufacturers of the district, and on their promise to raise a subscription for him, consented to let the trade have the advantage of his invention. The sum he obtained was something short of £60, and he lost the chance of ever making another penny by his machine. Sir Robert Peel, the father of the eminent statesman, accompanied by two mechanics, visited the "Hall i' th' Wood," and after having examined and measured Crompton's machine in every detail, the rich manufacturer graciously signified to the poor inventor that the great firm of Peel, Yates & Co., would subscribe one guinea to the fund for compensating Crompton for robbing him of the fruit of his five years' labour, and, in addition to that, gave him sixpence a piece for the two workmen who had made the examination and taken the measurements. After that, it was not surprising that the firm of Peel, Yates & Co., were able to make mules of their own just as well as Crompton. How keenly the inventor felt this injustice is shown by his own words to Mr. Ashworth: "If Peel, or any of his men," he said, "had taken away a rail or any portion of my machine it would have been a theft, and I cannot but feel that

Peel, when he thus came with his workmen and carried away the product of my brain, was a thief too." Crompton never forgave Peel, although the latter subsequently offered him first a situation of trust, and then a partnership, in his firm.

In declining Peel's offers Crompton lost the only opportunity he ever had of making a fortune. From that time forward he was a gloomy, discontented man. Many improvements were effected by others in Crompton's mule (so-called because it was a kind of hybrid between Hargreaves' jenny and Arkwright's water-frame), but the principle of the spindle-carriage, the one remarkable feature of the invention, was retained in all; and while the spinners of Lancashire were making gigantic fortunes by the use of the machine, the man who had devised it was lingering in poverty. John Bright once said, "We should relapse into barbarism if Crompton's spindle-carriage were taken away."

As a business man Crompton was a failure, and after the manner in which he had been filched of his spinning-machine, he did not feel any further encouragement to go on inventing. He occupied himself for a short time, it is true, with a carding-machine; but one day, the wrongs of the past so stirred the spirit of indignation within him that he took up his axe and broke the machine to pieces, saying, "They shall not have this too!" A subscription was set on foot for him during a time of severe distress, and from four to five hundred pounds were obtained for him. Then Parliament was approached on his behalf. In the petition that was presented it was shown that a sum of £300,000 a year was contributed to the revenue by the number of his mules then at work. One honourable member, it is said, on the matter coming up for consideration, said, "Oh, give the man £100 a year; it is as much as he can drink." Crompton went to London to urge his claims, and the matter was put into shape for him by friendly hands. While he was in the lobby of the House with Sir Robert Peel and Mr. Blackburn, Mr. Perceval, who was then Chancellor of the Exchequer, came up and said, "You will be glad to hear that we mean to propose £20,000 for Crompton; do you think that will be satisfactory?" Crompton walked shyly aside, so as not to hear the reply, and Perceval passed forward. The next moment a cry of horror was raised. The Chancellor of the Exchequer had been shot by Bellingham. This tragic incident made it necessary that the proposal in reference to Crompton should be withdrawn for that night. When the subject came up again a few days afterwards, a sum of £5,000 only was proposed, and this was the amount awarded. An attempt was subsequently made to obtain a larger reward, but Sir Robert Peel opposed the motion, and there the matter ended. Crompton died in 1827, at the age of seventy-four, after having been reduced to poverty again by business losses and domestic troubles. From the day that he gave up his invention to the day of his death his life was one long disappointment, greatly embittered by the ingratitude of those who had benefited by his invention.

The lives of these martyr-inventors carry with them lessons of deep import to such as follow in their footsteps, but the bonds of sympathy are now drawn so much closer between all sections of the industrial community, that instances of similar hardship can scarcely occur again.

CHAPTER IV.

INVENTORS IN POETRY AND FICTION.

The Missing Poet—The Wonderland that awaits the coming Laureate of Invention—Homer, Shakespeare, and Milton in connection with Matters of Invention—Inventions foreshadowed by the Poets—Strada's Notion of Magnetic Communication—Akenside's Imaginative Picture of the "Two Faithful Needles"—Erasmus Darwin's Vision of the Steamboat and the Locomotive—Drayton's Denunciation of the Iron Times—Dryden's Praise of Mechanical Progress—Cowper on the Birthday of Invention—"The Flatting Mill"—Dyer and the Spinning Machine—Dr. Darwin and his Floral Symbols of Mechanical Operations—Inventor-Poets—Cartwright, Telford, Crosse—"The Song of Steam" —Anderson's "Songs of the Rail"—Ruskin's View of Invention—The Inventor-Heroes of Fiction.

OF the invention which is the offspring of fancy, we have, perhaps, enough and to spare. Invention, however, of the more material sort has hardly had justice done to it by men of letters. The glories and horrors of "contumelious, mad-brained war" have always been an inspiring theme of song; pleasures of every kind—of Hope, of Memory, of the Imagination, of Indolence—have been celebrated by our poets; the pastoral and mock-pastoral, the nature-worshipping, the art-entranced, and the social phases of existence, have all had their lights and shadows limned by the pencils of immortal genius; but the laureate of Invention has not yet loomed upon the literary horizon. While the whole aspect of civilisation has been undergoing changes of mighty import, while steam has been exerting its wonder-working powers in almost every sphere of man's action, while electricity has been annihilating time and space, and gilding the darkness of night with the light of day, the poet, instead of allowing himself to be spurred to loftier flights by these marvels of man's intellectual conquest, has clung to his ancient ways—his petty loves and hates, his mild philosophisings, and small dreamings; and the giant forces around him, and the rush and roar of the inventive impulses of the time, he has almost entirely neglected. When the poet of Invention arises, one

> "With the touch of the gods on his lips,
> And his heart beating wild and quick,"

he will crystallise into undying intensity the movement and grandeur of this mighty age.

The poets of the past have not been altogether insensible to the material changes which invention has wrought from time to time, but they have hardly done more than make passing allusion to them; seldom, indeed, have they allowed them to act as themes of inspiration. Homer, in his description of the shield of Achilles, and in his allusion to the gilding and other processes of the time of which he wrote (or, more properly, perhaps, of the time *in* which he wrote), has kept a glow of poetic light round the inventive powers of those ancient days; and other classic poets have here and there made reference to things which are so much living evidence to these later times of the early arts and industries. We must come down to more recent times, however, to get at anything like direct poetic dealings with matters of invention. Gunpowder, that great invention of the Middle Ages, aroused Titanic vibrations both in Shakespeare and Milton. It is in *Henry IV.* that we find the lament:

"That villainous saltpetre should be digg'd
Out of the bowels of the harmless earth,
Which many a good tall fellow had destroy'd
So cowardly."

Milton ascribes the invention of this death-dealing compound to the arch-fiend himself; and when Satan tells how he has found

"Deep under ground, materials dark and crude,
Of spirituous and fiery spume, till touch'd
With heaven's ray, and temper'd, they shoot forth
So beauteous, op'ning to the ambient light,"

his peers are stirred to envy.

"Th' invention all admired, and each, how he
To be th' inventor miss'd; so easy it seem'd
Once found, which yet unfound one would have thought
Impossible."

There is a wonderfully human touch in these last lines, a sort of prescience of all inventive experience. Perhaps more astonishing than this, though, is the reference which the "cunning man, hight Sidrophel," makes in *Hudibras*, when he speaks of firing

"A mine in China, here,
With sympathetic gunpowder."

This, whether really a suggestion of electrical power, or a mere flight of imagination, is not to be lightly passed by. There were, however, embryotic notions of electricity afloat in Butler's time, and the poet may simply have touched one of these with the light of his fancy. The poets have often seemed to foreshadow great inventions which, long after their deaths, have been realised, and this makes it all the more surprising that they have not had their sympathies more earnestly aroused by the inventions of their own time. Solomon has a poetical passage in which Harvey's discovery of the circulation of the blood is supposed to be anticipated; Ben Jonson has described the submarine engine of warfare which we call the torpedo; Drummond of Hawthornden imagined projectiles and weapons of warfare which were not seen in actuality for nearly three centuries after his death; and Shakespeare would almost appear to have hinted at the law of gravitation, with the discovery of which Sir Isaac Newton's name is for ever associated. Steam and electricity were undoubtedly rudely germed in the brains of many poets, long before those agencies were thought out into the shape of assertive force. Milton has a vision of chariots "winged," moved by vital impulse, strongly suggestive of the locomotive,—

> "harness'd at hand,
> Celestial equipage; and now came forth
> Spontaneous, for within them spirit lived."

Strada's notion of magnetic communication, which may almost be considered the starting point of practical ideas in connection with the electric telegraph, was little more than a poetic conceit, but being expressed more than two centuries ago was greatly in advance of his time. Even Akenside, who, nearer our own day, attempted to put this idea into fuller shape in his now little read "Pleasures of the Imagination," can never have dreamed of such a thing as the electric telegraph becoming a reality. The poet says:—

> "If ancient fame the truth unfold,
> Two faithful needles, from the informing touch
> Of the same parent stone, together drew

Its mystic virtue, and at first conspired
With fatal impulse quivering to the pole;
Then, though disjoined by kingdoms, though the main
Rolled its broad surge betwixt, and different stars
Beheld their wakeful motions, yet preserved
The former friendship, and remembered still
The alliance of their birth. Whate'er the line
Which one possessed, nor pause nor quiet knew
The sure associate, ere, with trembling speed,
He found its path, and fixed unerring there."

The steam-engine of James Watt was known when Erasmus Darwin wrote his "Botanic Garden," but the steamboat and the locomotive were still hidden in the dimness of the future. His references to these inventions are, therefore, to be reckoned amongst the prophetic utterances of the poets. The precise condition of steam discovery may be gathered from a footnote which Dr. Darwin prints. "There is reason to believe," he says, "it [steam] may in time be applied to the rowing of barges, and the moving of carriages along the road." The lines in which poetic embodiment is given to this fancy run thus:

"Soon shall thy arm, unconquer'd Steam, afar
Drag the smooth barge, propel the lumbering car,
Or on wide-waving wings expanded bear
The flying chariot through the fields of air."

Chaucer and Ben Jonson had much to say in deprecation of those self-deluded inventors, the alchemists, but we do not get much direct dealing with the poetry of invention until we come down to the time of the steam-engine. Drayton's calm spirit was much disturbed by the ironworkers of the Weald of Sussex, whose incessant rattle, day and night, prevented indulgence in the more agreeable sylvan delights. He cries:

"These forests, as I say, the daughters of the Weald
(That in their heavy breasts had long their griefs concealed),
Foreseeing their decay each hour so fast come on,
Under the axe's stroke fetched many a grievous groan,
When as the anvil's weight and hammer's dreadful sound
Even rent the hollow woods and shook the queachy ground,
So that the trembling nymphs, oppress'd through ghastly fear,
Ran madding to the Downs with loose dishevell'd hair."

And then he goes on to describe how "the Sylvans that about the neighbouring woods did dwell" were "expelled their quiet seats,"

"When labouring carts they saw to hold their daily trade,
Where they in summer wont to sport them in the shade,
Could we (say they) that any would *us* cherish,
Which suffer (every day) the holiest things to perish?
Or to our daily want to minister supply?
These Iron Times breed none that mind posterity."

In a very different strain wrote Dryden of the ship-building operations of his day, into the details of which he entered almost as particularly as Dr. Darwin did into the mechanical processes of a century later. "Glorious John" says:

"Some the galled ropes with dauby marline bind,
Or sere-cloth masts with strong tarpaulin coats;
To try new shrouds one mounts into the wind,
And one below their ease or stiffness notes."

He also describes how

"Their left hand the caulking-iron guide,
The rattling mallet with the right they lift."

Cowper had a mind in entire sympathy with progress, and paid many a warm tribute to invention. In the opening lines of "The Task," he forcibly contrasts the remote past with the inventive present. He sings:

> "Time was, when clothing sumptuous or for use,
> Save their own painted skins, our sires had none.
> As yet black breeches were not; satin smooth,
> Or velvet soft, or plush with shaggy pile:
> The hardy chief upon the rugged rock
> Washed by the sea, or on the gravelly bank
> Thrown up by wintry torrents roaring loud,
> Fearless of wrong, reposed his weary strength.
> Those barbarous ages past, succeeded next
> The birthday of Invention, weak at first,
> Dull in design, and clumsy to perform.
> Joint-stools were then created; on three legs
> Upborne they stood: three legs upholding firm
> A mossy slab, in fashion square or round.
> On such a stool immortal Alfred sat,
> And swayed the sceptre of his infant realms."

In another poem, "Charity," he speaks of trade as "the golden girdle of the globe," and of commerce importing "what others have invented well;" while amongst his more pointed pictures of mechanical processes there is a very happy one, with a duly pointed moral, in his little poem, "The Flatting Mill":

> "When a bar of pure silver or ingot of gold
>   Is sent to be flatted or wrought into length,
> It is passed between cylinders often, and rolled
>   In an engine of utmost mechanical strength.
>
> "Thus tortured and squeezed, at last it appears
>   Like a loose heap of ribbon, a glittering show,
> Like music it tinkles and rings in your ears,
>   And, warmed by the pressure, is all in a glow.

"This process achieved, it is doomed to sustain
The thump after thump of a gold-beater's mallet,
And at last is of service in sickness or pain
To cover a pill for a delicate palate.

"Alas for the poet! who dares undertake
To urge reformation of national ill,
His head and his heart are both likely to ache,
With the double employment of mallet and mill."

There are many other instances scattered about our poetic literature of this and the previous time of the recognition of inventive improvements; but it is not until the steam-engine comes, startling the world out of its dreamy lethargy, that the poet is tempted to sing a few strains of earnest purpose and exultation in honour of the great mechanical achievements of the time. In no instance, however, did a poet of the first rank derive inspiration from the new forces; still, some of those smooth versifiers, whose highest ambition was to measure off poetic thoughts in unexciting heroic couplets, were at great pains to describe in verse the working of this new world of machinery.

Dyer, in "The Fleece," published in 1757, describes, with singular accuracy, Lewis Paul's machine for spinning by rollers. He refers to it as

"A circular machine, of new design,
In conic shape: it draws and spins a thread
Without the tedious toil of needless hands.
A wheel, invisible, beneath the floor,
To ev'ry member of th' harmonious frame
Gives necessary motion. One, intent,
O'erlooks the work; the carded wool, he says,
Is smoothly lapp'd around those cylinders,
Which, gently turning, yield it to yon cirque
Of upright spindles, which, with rapid whirl,
Spin out in long extent an even twine."

Dr. Darwin is, however, far away at the head of the poets of invention, for there was not an invention of note of his day that he did not attach in some pretty way to the flowers of his "Botanic Garden," seeing symbols of every machine and mechanical operation in the floral beauties of nature. We have already seen how he was prompted into the prophetic vein by the contemplation of steam; let us now note what he said concerning the perfected accomplishments of that power:

"Nymphs! you erewhile on simmering cauldrons played,
And called delighted Savery to your aid;
Bade round the youth explosive steam aspire,
In gathering clouds, and wing'd the wave with fire;
Bade with cold streams the quick expansion stop,
And sink the immense of vapour to a drop.
Press'd by the ponderous air the piston falls,
Resistless, sliding through its iron walls;
Quick moves the balanced beam, of giant birth,
Wields his large limbs, and nodding shakes the earth."

In connection with the flax-plant, Dr. Darwin makes mention of the linen loom. He exclaims:

"Inventress of the Woof, fair Luna flings
The flying shuttle through the dancing strings;
Inlays the broider'd weft with flowery dyes,
Quick beat the reeds, the pedals fall and rise;
Slow from the beam the lengths of warp unwind,
And dance and nod the massy weights behind."

The cotton-plant inspires him similarly in regard to the cotton manufacturing processes, which he depicts with no less completeness, describing how,

"With wiry teeth revolving cards release
The tangled knots, and smooth the ravell'd fleece;"

how

"——the iron hand with fingers fine
Combs the wide card, and forms the eternal line;"

and how,

"With quicken'd pace successive rollers move,
And these retain, and those extend the rove;
Then fly the spoles, the rapid axles glow,
And slowly circumvolves the wheel below."

In another part, the poet apostrophises the inventor of the balloon,

"Rise, great Montgolfier! urge thy venturous flight
High o'er the moon's pale ice-reflected light;"

and, apropos of the carline-thistle, describes the aeronaut in the following terms:

"So on the shoreless air the intrepid Gaul
Launch'd the vast concave of his buoyant ball;
The calm philosopher in ether sails,
Views broader stars, and breathes in purer gales."

He also alludes to Wedgwood's "New Etruria" that "decks Britannia's isles," and thus addresses the potter:

"Charm'd by your touch, the flint liquescent pours
Through finer sieves, and falls in whiter showers;
Charm'd by your touch, the kneaded clay refines,
The biscuit hardens, the enamel shines;
Each nicer mould a softer feature drinks,
The bold cameo speaks, the soft intaglio thinks."

Brindley also receives the homage of Dr. Darwin's pleasant verse:

"So with strong arm immortal Brindley leads
His long canals, and parts the velvet meads."

Well may the Bookseller, with whom the poet has a little dialogue, by way of interlude. from time to time, express his astonishment at such unusual poetical figures. "The monsters of your Botanic Garden," he says, "are as surprising as the bulls with brazen feet, and the fire-breathing dragons, which guarded the Hesperian fruit; yet they are not disgusting, nor mischievous; and in the manner you have chained them together in your exhibition, they succeed each other amusingly enough, like prints of the London Cries, wrapped upon rollers, with a glass before them."

The inventors themselves occasionally soared into song when the world was a century younger. Dr. Cartwright, the inventor of the power loom, had the distinction of being the first live poet Sir Walter Scott ever set eyes upon. "I have a vision," wrote the author of "Waverley," "of having met this accomplished gentleman in my very early youth, and am the less likely to be mistaken, as he was the first living poet I recollect to have seen." Cartwright's poetry was much admired by Dugald Stewart, who was wont to quote, with much pathos, the picture of resignation in the following stanza:

"And while his eye to heaven he raised,
Its silent waters stole away."

He was possessed of no common mind who could, in the hour of disappointment, when some inventive scheme had been frustrated, sit down and pen a sonnet like the following:

"With sails expanding to the gales of hope,
  My venturous bark pursued her leading star;
Hers was a voyage of no common scope,
  A voyage of discovery, distant far!
To bright Invention's intellectual clime,
  In search of useful arts 'twas mine to roam.

I reach'd the object of my views sublime,
And, richly freighted, bore my cargo home:
My friends expectant fill the crowded strand.
But ere I gain the shore what storms arise,
My vessel founders e'en in sight of land,
And now a wreck upon the beach she lies!
With firm, unshaken mind that wreck I see,
Nor think the doom of man reversed for me."

And there is a touch of sublimity in the verses he wrote when nearly at the close of his earthly career, in which he sang

" I cleave to earth, to earth-born cares confined,
A worm of science of the humblest kind.
With mind unwearied still will I engage,
In spite of failing vigour and of age;
Nor quit the conflict till I quit the stage."

Edmund Cartwright was a sort of universal genius, —poet, philosopher, parson, inventor, doctor; but it is as the inventor that he will chiefly be remembered, although it was no small tribute to his poetic gifts that his poems ran through twelve editions, his legend of " Armine and Elvira" having passed through seven editions in the first year of its publication.

Telford wrote verse, too, but it was imitative of Burns rather than the outcome of any original thought of the engineer's. At all events, it was not his life's work that gave him his verse-promptings. Sennefelder, the inventor of lithography, was not only a poet but a playwright; but he seems to have failed miserably in the cultivation of the imagination. Andrew Crosse, the electrical chemist, also indulged in poetical exercises; but here again the labours of the poet did not inspire his muse. In some stanzas of his addressed to "The Chamber Clock," there occur the following not unmusical verses:—

"Beat! beat! in love or strife—
Every beat is a slice of life;
And when the listener's dead and gone,
Another shall hear the clock beat on."

There have been many poets who have rushed into verse to the stirring tune of the steam-engine's quivering beat, and some have seemed to catch the spirit of the mighty power; but few poems stand out as worthy of the subject. Much of the poetry of the steam-engine and the locomotive has been about up to the level of the lines in which the failure of Jonathan Hull's steamboat was celebrated in 1736:

"Jonathan Hull,
With his paper skull,
Tried hard to make a machine
That should go against wind and tide;
But he, like an ass,
Couldn't bring it to pass,
So at last was ashamed to be seen."

Perhaps the nearest approach to a sustained poem on the might of steam is the following production of an American poet, which is called simply the

SONG OF STEAM.

"Harness me down with your iron bands;
Be sure of your curb and rein,
For I scorn the power of your puny hands
As the tempest scorns a chain.
How I laughed, as I lay concealed from sight
For many a countless hour,
At the childish boast of human might,
And the pride of human power.

"When I saw an army upon the land,
A navy upon the seas,
Creeping along, a snail-like band,
Or waiting the wayward breeze;

When I marked the peasant faintly reel
With the toil which he daily bore,
As he feebly turned at the tardy wheel,
Or tugged at the weary oar.

"When I measured the panting courser's speed,
The flight of the carrier dove,
As they bore the law a king decreed,
Or the lines of impatient love,
I could not but think how the world would feel,
As these were outstripped afar,
When I should be bound to the rushing keel,
Or chained to the flying car.

"Ha! ha! ha! they found me at last;
They invited me forth at length,
And I rushed to my throne with a thunder blast,
And laughed in my iron strength.
Oh! then ye saw a wondrous change
On the earth and ocean wide,
Where now my fiery armies range,
Nor wait for wind or tide.

"Hurrah! hurrah! the waters o'er,
The mountain's steep decline;
Time—space—have yielded to my power—
The world! the world is mine!
The rivers the sun hath earliest blest,
Or those where his beams decline;
The giant streams of the queenly west
Or the orient floods divine.

"The ocean pales where'er I sweep,
To hear my strength rejoice;
And the monsters of the briny deep
Cower, trembling at my voice.
I carry the wealth and the lord of earth,
The thoughts of the god-like mind;
The wind lags after my flying forth,
The lightning is left behind.

In the darksome depths of the fathomless mine
My tireless arm doth play
Where the rocks never saw the sun decline,
Or the dawn of the glorious day.
I bring earth's glittering jewels up
From the hidden cave below,
And I make the fountain's granite cup
With a crystal gush overflow.

"I blow the bellows, I forge the steel
In all the shops of trade;
I hammer the ore and turn the wheel
Where my arms of strength are made;
I manage the furnace, the mill, the mint—
I carry, I spin, I weave;
And all my doings I put into print
On every Saturday eve.

"I 've no muscle to weary, no breast to decay,
No bones to be 'laid on the shelf;'
And soon I intend you may 'go and play,'
While I manage the world by myself.
But harness me down with your iron bands,
Be sure of your curb and rein,
For I scorn the strength of your puny hands
As the tempest scorns a chain."

In recent times Alexander Anderson, the Scottish "surface-man" poet, has, in his "Songs of the Rail," struck the true chords of fire; and if he has not made them vibrate with that fuller force which the theme demands, he has, at least, stirred them to poetic thrillings, and has thrown much of the vigour of the locomotive into his verse. This is how this humble poet sings of his king, the engine:

"Hurrah! for the mighty engine,
As he bounds along his track;
Hurrah! for the life that's in him,
And his breath so thick and black;

And hurrah! for our fellows, who in their need
Could fashion a thing like him—
With a heart of fire, and a soul of steel,
And a Samson in every limb.

* * * * * *

"Ay, give me the heat of his fire-red breast,
And the shake of his giant frame,
And the sinews that work like the shoulders of Jove
When he launches a bolt of flame;
And give me that Lilliput rider of his,
Stout, and wiry, and grim,
Who can vault on his back as he puffs his pipe,
And whisk the breath from him."

But even Alexander Anderson has to confess that the true poet of the steam-engine is yet unborn, for he shouts, with his last hurrah:

"Then hurrah! for our mighty engine, boys;
He may roar and fume along
For a hundred years ere a poet arise
To shrine him in worthy song!"

Mr. Anderson has, in a vein of richer fancy, sung the song of the Wires, in which he acts as interpreter to their voices of joy and sorrow, death and life. Mr. Cholmondeley Pennell has also chanted a vigorous "Song of the Rail" in his "Puck on Pegasus."

Many have been the poets of labour, but the epic of invention is still unwritten. Schiller's "Lay of the Bell," and Longfellow's "Building of the Ship," are worthy contributions to the poetry of invention; and Tennyson and Browning have culled some singularly felicitous images and thoughts from the inventive field; but it has been left to the minor poets hitherto to sing the songs of steam, and fire and iron, of looms, and spindles, and wheels. The Laureate has told us, however, that

> "'All the years invent,
> Each month is various to present
> The world with some development;'"

so in time we may even be able to welcome the poet of invention.

In some of that noble prose poetry of lamentation of which Mr. Ruskin is so complete a master, there are some references to the great inventions of the age which are not quite so inspiriting as the "Song of Steam." What is the good of it all? Mr. Ruskin seems to be for ever asking. "No changing of place at a hundred miles an hour," he says; "no making of stuffs a thousand yards a minute, will make us one whit stronger, happier, or wiser." And he adds: "Your railroad, when you come to understand it, is only a device for making the world smaller, and as for being able to talk from place to place, that is, indeed, well and convenient; but suppose you have originally nothing to say?" But in the thirty years that have elapsed since Mr. Ruskin wrote those words in his "Modern Painters," it has been shown that the world *is* "stronger, happier, and wiser" for the inventions which its sons of science have given it; and, above all, that the "something to say" has been made more eloquent, more impressive, and more comfort-yielding by these advantages of conquest over time, space, and nature.

In the world of fiction there have been many heroes of invention, but they are nearly all of the stereotyped pattern: poor, struggling, despised beings, sometimes possessed of a good idea, but more often the victims of self-delusion. Dickens has done much to awaken sympathy for the poor inventor, and especially for the victims of the patent office ; Charles Reade, George Eliot, Lord Lytton, John Saunders, and others, have followed on somewhat similar lines. And in the wilder regions of fiction, where adventure and allegory alternate, the rein of imagination has known no curb in working out inventions ; Rabelais and Swift occupy front places in one of these branches, Daniel Defoe and Jules Verne the prominent positions of the other.

CHAPTER V.

INVENTORS IN PHANTOM-LAND.

Impossible Tasks—The Pursuit of Phantoms—The *ignis fatuus* of Perpetual Motion—Great Mechanical Geniuses who have been dazzled by it—The Marquis of Worcester's Perpetual Motion Machine—Orffyreus and his Three Hundred Machines—Earlier Dabblers in this "Sea of Trouble"—The Wasted Efforts of Arkwright, Stephenson, and others—The Eternal Lamp—The Story of the Lamp of Rosicrucius—Mr. G. J. Knox and his Ever-burning Flame—Richard Trevethick—His Muscular Feats—The Thames Driftway Tunnel and Trevethick's Proof conclusive — Trevethick's Romantic Adventures in Peru — Made a Marquis and Grandee of Old Spain—Don Ricardo's Downfall—His Meeting with Robert Stephenson at Cartagena—Return to England—His Final Day-dream and Death—Other Inventor-dreamers.

THERE is no day-dreamer capable of going such lengths in pursuit of nothing as the inventor whose mind has been set upon the accomplishment of an impossible task. Having deluded himself into the belief that the thing which he aims at is not only attainable, but worthy of attainment, it matters not to him that the *ignis fatuus* which he is so eagerly chasing has led others the way of disappointment and failure, perhaps of destruction. He thinks himself reserved for a better fate, and the possessor of a deeper knowledge; and so he goes on through his dream, the wasted years falling behind him one by one, until the sting drops, and he awakes at last to the desolation of despair. The hero of Tennyson's *Sea Dreams*, who, on the breaking of a glass at his bedside, experienced a fantastic vision of a fleet of glass ships drifting to wreck upon a reef of golden rocks, had as substantial a basis for his fancies as the inventor has, who makes a dream of his whole career by devoting himself to a mechanical problem that does not admit of solving, or which, if solved, would add nothing to the world's power, knowledge, or wealth. There is often a suggestion of at least mental balance in the dreams that "are the interludes which fancy makes." As Dryden has it:

> "When monarch Reason sleeps, this mimic wakes,
> Compounds a medley of disjointed things,
> A court of cobblers, or a mob of kings;"

but in the day-dreams of the inventor it is fact which becomes the slave of a disordered fancy.

The phantom which false inventors have most persistently pursued is the phantom of perpetual motion. Great minds have occasionally touched this seeming riddle, but have soon thrown it aside as a useless folly, and betaken themselves to more profitable investigations. Some one (a Yankee, probably) has recommended that before any man sets out to invent perpetual motion he should practise the trick of getting into a basket and lifting himself by the handles. "When he succeeds at that," it is added, "he can go ahead with perpetual motion with some prospect of success." This is the common-sense notion of an unmechanical mind; but the scientific mind arrives at a conclusion very much akin to it when it says that it is useless to attempt to create power out of nothing.

Still, so many men of high mechanical genius have been dazzled by this idea of perpetual motion, and so many thousands of models have been constructed as embodiments of the principle, that, much as we may regret the waste of time represented by these efforts, we are bound to respect the sincerity which has prompted them. Mr. Henry Dircks, with praiseworthy diligence, has collected in a couple of volumes, under the title of *Perpetuum Mobile*, descriptions of many of the perpetual motion machines—gathered from the patent records in the majority of instances—from which it will be seen that, in spite of all the failures of the past, and the repeated demonstration, by eminent men of science, of the illusory nature of the theory, experimenters in perpetual motion are still a numerous though scattered body, and there seems to be no likelihood of the race dying out. According to our authority, letters patent for some two hundred mechanical contrivances for perpetual motion have been taken out during the present century, "combining levers, wheels, weights, water, and air, to accommodate the whimsical fancies of men pretending both to rationality and some scientific knowledge." And he mentions that amongst the patentees are "a colonial bishop, a professor of philosophy, and another of languages, two barons, a knight of the most noble order of the Temple, four military men, a doctor of medicine, a barrister, two civil engineers, several mechanical engineers, a brass manufacturer, miller, millwright, smith, saddler, bobbin manufacturer, surveyor, and a geologist, besides others whose professions are not named."

Glancing rapidly across this wilderness of wasted effort, defeated hopes, and human folly, we find enthusiasts and detractors ranged in opposition to each other on this question all through, much the same as they have been in regard to greater matters. While inventors in the olden time were bending all their powers to create this something out of nothing by water, mercury, levers, screws, wheels, inclined planes, sand, quicksilver, and what not, philosophers, poets, and men of science were found in plenty to oppose and ridicule their mechanical speculations. It was asserted by some that perpetual motion was a lost invention; by others that it had never yet been found; and so the contention went on from century to century, neither side being converted by the other.

The two names which stand out most prominently in the past in connection with experiments in perpetual motion are those of the Marquis of Worcester, and Orffyreus, of Hesse Cassel. The versatile author of the "Century of Inventions" constructed a machine, the wheel of which, fourteen feet in diameter, was rotated by the action of forty 50 lb. weights. This was a rather gigantic affair, and required a very strong framework for its support. There is no record of the achievements of this particular machine, however, so that we have no means of knowing how far on the road to perpetuity it succeeded in travelling. Of the machines of Orffyreus we are permitted to learn more. This indefatigable mechanician, who was of humble origin, and lived from the latter part of the seventeenth to the middle of the eighteenth century, made nearly 300 different machines, it is said, all planned with the object of establishing the theory of perpetual motion. He had a princely patron who was desirous of obtaining from these experiments results which might be utilised for manufacturing and other operations. The inventor claimed for the last machine that he made that it completely solved the problem; but an unfortunate misunderstanding with the prince caused him to decline to bring it forward, and from that time to the day of his death in 1745 (a period of twenty-eight years) he preserved the silence of the grave in respect of the details of his *magnum opus.* The wheel was said to be twelve feet in diameter, and fourteen inches broad, and would revolve either way. It was, moreover, described as being capable of raising a weight of seventy pounds to a considerable height.

The earliest English inventor to dabble in perpetual motion was Willars de Honecort, in the thirteenth century, who thus boasted of a machine that he had constructed: "Many a time have skilful workmen tried to contrive a wheel that shall turn of itself; here is a way to make such a one, by means of an uneven number of mallets, or by quicksilver." The noted Dr. Dee has a curious note, in the preface to his Euclid, referring to an apparatus of an ancient date. He says: "By wheels, strange works and incredible are done, as will hereafter appear. A wonderful example of further possibility and present commodity was seen in my time, in a certain instrument, which by the inventor and artificer (before) was sold for twenty talents of gold, and then had (by misfortune) received some injury and hurt. And one Janellus of Cremona did mend the same, and presented it unto the Emperor Charles the Fift. Hieronymus Cardanus can be my witnesse, that therein was one wheel which moved, and that in such rate, that, in 7,000 years, only his own period should be finished. A thing almost incredible; but how farre I keep me within my bounds very many men (yet alive) can tel."

It is well known that Leonardo da Vinci employed his great talents in devising schemes for perpetual motion, and that a machine for this end was made for

James I. of England by Cornelius Drebbel. In the last-named apparatus the revolutions of the sun and moon were represented, and "that without the help either of springs or weights." We obtain information respecting this from one Thomas Tymme, "who was a familiar acquaintance of his, and did often pry into his works (as he professes himself), who affirms it to be done thus: by extracting a fiery spirit out of the mineral matter, joining the same with his proper air, which included in the axle-tree (of the first moving wheel), being hollow, carrieth the other wheels, making a continual rotation, except for issue a vent be given in this hollow axle-tree, whereby the imprisoned spirit may go forth." It is added, with a quaintly expressed hint of disbelief: "What strange things may be done by such extractions I know not, and therefore dare not condemn this relation as impossible; but methinks it sounds rather like a chymical dream than a philosophical truth." Peter Perigrinus expressed the opinion ("and there was an example pretended for it in Bettinus") that "a magnetical globe, or terella, being rightly placed upon its poles, would of itself have a constant rotation, like the diurnal motion of the earth." Joannes Taisnierus, Jacob Leupold, Dr. Papin, and Dr. Hooper, are other names that deserve enumeration amongst the more distinguished searchers after perpetual motion. Dr. Hooper described "a clock to go perpetually by the influence of the celestial bodies." An eminent engineer named Schlüter received an offer from the king of Prussia, in 1730, of 30,000 roubles, "if he, or any other, would find out perpetual motion."

Amongst those who have attempted by serious argument to convince perpetual motion enthusiasts of the error of their ways, was the French mathematician and astronomer, Philip de la Hire, who in the seventeenth century offered a demonstration on the impossibility of perpetual motion, to discover which, he said, "would be to discover a body at once heavier and lighter than itself;" and he adds, "I could almost as readily impute ingenuity to vegetables and fossils, to the sensitive plant and the loadstone, or meditation to mussels, or cogitativity to cockles, periwinkles, and rock oysters!" Bishop Wilkins, about the same time, discussed "the seeming facility and real difficulty of any such contrivances" as perpetual motion. But neither serious criticism nor ridicule sufficed to frighten the enthusiasts from their experiments; nothing could convince them but time and experience that they were engaged in a fruitless undertaking.

It was claimed at one time that John Spence, of Linlithgow, had accomplished the great task on which so many had been vainly engaged; but it was ultimately confessed that his invention was "rather a practical development of the principle than the application of any useful purpose." This apparatus consisted of a wooden beam, poised by the centre, and had a piece of steel attached to one end of it, which was alternately drawn up by a piece of magnet placed above it, and down by another placed below it; and as the end of the beam approached the magnet, either above or below, a machine interjected a non-conducting substance, which suspended the attraction of the magnet approached, and allowed the other to exert its powers.

Arkwright was for a time a victim of the perpetual motion craze, and although he soon found out the utter uselessness of his efforts, he acknowledged that his experiments were beneficial to him in so far as they gave him a further insight than he had previously possessed into the secrets of mechanism. George Stephenson began his experiences as an inventor with the perpetual motion problem while at Willington, and constructed a model of a machine which was to accomplish the desired object. His biographer describes it as consisting of "a wooden wheel, the periphery of which was furnished with glass tubes filled with quicksilver ; and as the wheel rotated, the quicksilver poured itself down into the lower tubes, and thus a sort of self-acting motion was kept up in the apparatus, which, however, did not prove to be perpetual." This was his first perpetual motion machine. He afterwards made several others, but with no better result ; and finally he came to the conclusion that he had been deluding himself with a useless mechanical toy. He often, we are told, used to "lament the time he had lost in these futile attempts."

In the last century Katterfelto, the conjurer, used to exhibit a perpetual motion machine along with his other attractions:

> "Katterfelto, with his hair on end,
> At his own wonders wondering for his bread."

He was accustomed to announce himself as being "accompanied by his wonderful Morocco black cat—an animal of much merit, which gained him at one time in London £3,000," and to declare that in addition to showing his "various occult secrets," which had "much surprised the learned and many kings and queens of Europe," he would exhibit "his grand mechanical exhibition and perpetual motion."

So recently as 1860, Sir John Trotter Bethune took out a patent for "Improvements in the production of motive power by application of the dead weight of liquids, and in the apparatus connected therewith." Indeed, not a year passes but some new enthusiast lodges at the Patent Office the specifications of a machine for perpetual motion. This is not in itself considered evidence of insanity, but it is unquestionably regarded by some as a proof of mechanical aberration. Only one fatality is reported as the direct outcome of the pursuit of perpetual motion, and that is the case of Hartmann, of Leipsic, who hanged himself in mortification and despair at having spent the best part of his life in prosecuting this hopeless aim.

The problem is no nearer solution to-day than it was five hundred years ago, still there are mechanicians to be found who believe it possible to accomplish it. If they would follow the advice of the late Professor A. de Morgan, there might be some hope for them. "The purse of Fortunatus," he says, "which could always drop a penny out, though never a penny was put in, is a problem of the same kind. He who can construct this purse may construct a perpetual motion, in this way: Let him hang the purse upside down, and with the stream of pence which will flow out let him buy a strong steam-engine, and pay for keeping it at work day and night."

Another invention round which the spell of dreams has been thrown is the eternal lamp; not a perpetual motion, but a perpetual illuminant. To get at a comprehension of this invention we have to dive deep into Rosicrucian mysteries, as well as into the ancient sepulchres of the East. The eternal lamps of the tombs, it was said, would continue burning without any waste so long as the air was excluded from them, but the moment the tomb was opened the flame would be extinguished, which rendered proof of eternal power rather difficult. In the middle of the sixteenth century, we are told, a tomb, supposed to be the burial-place of Cicero's daughter, Tullia, was opened, and in it was found a lighted lamp which must have been burning for at least 1,500 years. Many similar instances are cited, notably that of the lamp that was found burning in the tomb of Olybius Maximus, of Padua, which had also kept alight for 1,500 years. In this tomb, the story goes, two phials were found, one of gold and one of silver, both filled with a liquid of remarkable clearness, which fed the lamp, without any perceptible diminution of power. Several of these lamps are also supposed to have been discovered in subterranean vaults in England. The ancients are presumed to have possessed the secret of making inconsumable oil. Trithemius, who lived in the fifteenth century, invented an oil made of flower of brimstone, borax, and spirit of wine, for which he claimed immortal burning power. Kircher, the Jesuit, introduced asbestos wicks, and professed to be able to make a chemical preparation of gold which would burn for ever along with them. Roger Bacon and Dr. Plot were believers in eternal lamps.

But the most wonderful of these perpetual lamps is undoubtedly that of Rosicrucius, the founder of the Rosicrucians, the story of the finding of which we cannot do better than transcribe from Addison's

Spectator. The tale runs thus: "A certain person having occasion to dig somewhat deep in the ground, met with a small door, having a wall on each side of it. His curiosity, and the hopes of finding some hidden treasure, soon prompted him to force open the door. He was immediately surprised by a sudden blaze of light, and discovered a very fair vault. At the upper end of it was a statue of a man in armour, sitting by a table and leaning on his left arm. He held a truncheon in his right hand, and had a lamp burning before him. The man had no sooner set one foot within the vault than the statue erected itself from its leaning posture, stood bolt upright, and upon the fellow's advancing another step, lifted up the truncheon in his right hand. The man still ventured a third step; when the statue with a furious blow broke the lamp into a thousand pieces, and left his guest in a sudden darkness. Upon the report of this adventure, the country people soon came with lights to the sepulchre, and discovered that the statue, which was made of brass, was nothing more than a piece of clock-work; that the floor of the vault was all loose, and underlaid with several springs, which, upon any man's entering, naturally produced that which had happened. Rosicrucius, say his disciples, made use of this method to show the world that he had re-invented the ever-burning lamps of the ancients; though he was resolved no one should reap any advantage from the discovery."

A paper was read a few years ago at the Royal Irish Academy, by Mr. G. J. Knox, "On a Principle for producing an ever-burning flame," in which it was laid down that the desideratum for an everlasting lamp was that it should contain within itself a *renovating* principle, and this, it was maintained, was found in a thermo-electric arrangement by which water could be decomposed, and provision made for an unceasing recombination and condensation. This is probably as near an approach to an eternal lamp as is possible; but it is none the less an invention of dreamland, if for no other reason than that its endless light, if obtained, would be an endless inutility.

One of the most prolific inventor-dreamers of modern times was Richard Trevethick, the Cornish engineer, who, like the Marquis of Worcester, seems to have dreamed of inventions without end, great and small, practicable and impracticable. That there was method in much of his dreaming he sufficiently demonstrated in his lifetime, in connection with the steam-engine and many other inventions which he left others to work out from the dreamland of his fancy to the solid ground of fact. In his fertile brain were produced, with an embarrassing rapidity, thoughts of the steamboat, the locomotive, the screw-propeller, iron ships, the hydraulic crane, and other notable inventions, long before they were taken up by the men who afterwards perfected them. He was a giant, physically and mentally, but wanting in the sustaining power, patience, and wisdom, so necessary to the character-completion of the successful inventor. Of immense muscular strength, he could lift from the ground an iron mandril weighing half a ton, and could write his name on a beam six feet from the floor, with a fifty-six pound weight hanging from his thumb. He stood six feet high, and was broad in proportion; in his manners he showed a mixture of modesty and bluntness, imperiousness and tenderness, energy and restlessness; and was altogether a wayward, impulsive, highly imaginative genius. Mental ballast was the one quality he lacked. It was not to be wondered at that such a man should dream grand dreams, achieve great wonders, and explore the heights and depths of romance and poverty. After a mining dinner in Cornwall, being invited to a wrestling tussle with one Captain Hodges, a burly fellow six feet in height, he seized him by the middle, turned him topsy-turvy, and left the print of his shoes on the ceiling of the room. It has been said that Trevethick and William Murdoch once fought a duel, but this story is open to doubt. A fight in the orthodox pugilistic fashion would be much more to Trevethick's taste. He was a fighter, indeed, from first to last, a mechanical soldier of fortune.

In 1809 his dream was to make a driftway and tunnel under the Thames, from Rotherhithe to Limehouse. Other engineers had been at work before him in this scheme, but without success. He excavated at the rate of from four to ten feet a day, and after a year and a half's labour found he had advanced a thousand feet beneath the river, to near low-water mark on the north shore. And his dream might have come true but for that unruly temper of his. It was asserted by the surveyor to the Thames Driftway Committee that the tunnel had diverged a foot or so from the line laid down; not that it mattered much whether it had or not, but such was the fact, he said. Trevethick flew into a passion at what he considered to be a reflection upon his engineering skill, and insisted upon disproving the surveyor's statement. And now he allowed himself to be thrown off his balance completely, and committed an act of folly which neutralised all his previous efforts. He had a party of interested persons put in a boat and rowed to the exact line indicated on the plan, and then he himself went down into the tunnel and pushed a number of joint rods up through the roof, to be received by the people in the boat. It needed no man of genius to tell what the result would be; but Trevethick's ability had been impugned, and, come what might, he would show "that fool of a surveyor" that he was wrong. So he did, but at the same time he let the waters of the Thames into the tunnel and had to fly for his life, escaping with the water up to his neck. Trevethick's dream was afterwards taken up by Brunel, and, at a point about half a mile higher up the river and at a safer depth, was fully realised.

A year or two later Trevethick's imaginative mind was stirred with romantic visions which served to lift him for a while clean out of the world of struggle, failure, and prejudice which had become so unbearable to him. A gentleman from Lima, named Uvillé, interested in the silver mines of Peru, came over to England with the object of buying machinery for pumping the water out of the mines. In a shop window near Fitzroy Square he saw a small working model of one of Trevethick's pumping engines, bought it, and carried it back with him to South America. Having satisfied himself that with an engine constructed on this principle it would be possible to clear the water from the abandoned Peruvian mines, and having obtained the leave of the Viceroy to work them, he returned to England, saw Trevethick, and made him an offer to send some of his engines out to Peru. Trevethick wanted nothing better. Dreams of fabulous wealth rose before him, and he accepted the offer with all the enthusiasm of his nature. The result was that nine of Trevethick's engines, three engineers, and Uvillé, shortly afterwards embarked for Lima, where they in due course landed, being received with a royal salute. The engines, in detached portions, were placed on the backs of llamas, and transported across the mountains to the mines, Uvillé following in state. The new machinery did its work so well that Trevethick himself was sent for, and in 1817 he set sail for Lima. His fame had preceded him. When he landed he found the city *en fête* in his honour. Salutes were fired, flags were hoisted, and the Viceroy came forth to greet him ; and after being feasted and applauded to his heart's content, Trevethick made a sort of triumphal journey over the Cordilleras, escorted by a special guard of honour, and accompanied by the Lord Warden of the Mines. Arrived at the place where his engines were already so successfully working, he lost no time in still further improving their capabilities, and in making fresh machines for other purposes ; a coining machine that he constructed, amongst others, performing unparalleled marvels for the Peruvians. He increased the wealth of the country, and was, to all appearance, amassing riches for himself at a rate undreamed of in dull, slow-going England. News went across the sea to Cornwall that the emoluments of his office in Peru were £100,000 a year. Be that as it may, he was created a marquis and grandee of Old Spain, and as Don Ricardo Trevethick was honoured as the first of living engineers. A silver statue was proposed to be erected in memory of his achievements. And so for a year or two the Cornish inventor continued to enjoy his princely dream, and it seemed as if there was an end for ever of struggle and misfortune.

But it was too bright a dream to last. The shadow of revolution fell upon Peru while Don Ricardo was in the height of his prosperity, "chilling and killing" the hopes of the new grandee. For a time he was in his own person a bone of contention between Bolivar's party and the royalists, for he represented the "sinews of war." The former held him in a sort of privileged captivity as long as they could, while the latter endeavoured to make him useless to their enemies by breaking his engines, selling his shares, and disposing of his property. The upshot was, that Trevethick was glad to leave his golden dreams behind him and to make his escape, along with Uvillé. They were in peril of their lives at every step of their flight across the mountains, forests, and rivers of Peru, but at last succeeded in getting safely away from the country, the whole of Don Ricardo's colossal fortune being represented by the clothes he stood up in, and a pair of silver spurs.

He now made his way to Chili, where there did not happen to be a revolution going on at that particular period, and settled there until 1827, projecting engineering improvements and building another magnificent series of castles in the air. Here he became possessed of an estate with a mountain of copper ore in it, which he proposed to connect with the sea by means of a railway which should skim round precipices, bridge over chasms, and bore through impassable hills; but the dream faded, like the other dream, and there came a day when he was glad to turn his steps once more towards old England. He contrived to get as far on the homeward journey as Cartagena, when at the inn there luck threw him in the way of Robert Stephenson, who was on his way from Colombia to New York. What a meeting that must have been! Trevethick had not seen the younger Stephenson since the time he had nursed "Little Bobby" on his knee, in the Northumberland village where Trevethick and the Stephensons had first become acquainted. Robert Stephenson lent Trevethick £50, and with that the fallen grandee made his way home. But even yet there was not an end of his dreaming. Hearing that £100,000 was paid for ice from the Greenland seas, he came forward with a proposal to make artificial ice by evaporation; he also dreamed of a handsome pension from Government, for his services to the country as an inventor (services which in respect of the Cornish mines alone had effected a saving of £100,000 per annum), and he prepared a petition, but never presented it. Last of all, he put the crowning touch to his not altogether "baseless fabric" of dreams by projecting a national monument in honour of the Reform Bill of 1832, which monument was to take the shape of a stupendous circular column of cast-iron, gilt, to be 1,000 feet high, 100 feet in diameter at the base, and 12 feet at the top, to weigh 6,000 tons, and to cost £80,000. This monumental column was to be "symbolical of the beauty and strength, and unaffected grandeur of the British Constitution." And, above and beyond this, the structure was to have a central tube or cylinder, 10 feet in diameter, by which passengers were to be conveyed up and down by means of a piston urged by the pressure of the enclosed air and driven by a steam-engine. This was the final day-dream of one of the most remarkable men in the annals of modern mechanical activity. Two months afterwards he breathed his last, at Dartford, dying penniless, with no relation at hand to perform the last sad offices for him. His remains were borne to the grave by a body of mechanics from the works of Messrs. Hall.

So many notions that were supposed to be dreams of the most shadowy kind at the time they were first promulgated, have been ultimately realised, that even the sceptical have ceased to be over confident in the denunciation of such visions. Dr. Darwin spoke of the time when

> "Britain's sons shall guide
> Huge sea-balloons *beneath* the tossing tide;
> The diving castles, roof'd with spheric glass,
> Ribb'd with strong oak, and barr'd with bolts of brass,
> Buoy'd with pure air shall endless tracks pursue,
> And Priestley's hand the vital flood renew;"

closing with the picture of "obedient sharks" trailing the "sceptred car." This is still a dream, but he would be a bold man who would say that, with modifications, it would be impossible of fulfilment. In fact, if Boyle is to be believed, Cornelius Drebbel, who constructed the perpetual motion machine for James I., also planned for that monarch "a vessel to be rowed under water," as well as "a liquor to be carried in that vessel, which would supply the want of fresh air;" and, it is added, "it was tried *in* the river Thames." The evidence of all this becomes somewhat attenuated, though, when we read that "one of the persons who was in that submarine voyage told the particulars of the experiment to a person who related them to Mr. Boyle."

Railways under the sea and over the sea, have been amongst the more recent dreams of inventors.

The former, which was to have been constructed in the shape of the Channel Tunnel, has been temporarily condemned by military alarmists; the latter, which was once projected under the title of the Aërial Pontoon Railway Suspension Bridge, still rests in the obscurity of dreamland. But so long as the dreamers steer clear of such crotchets as perpetual motion and eternal lamps, they will now and then succeed in realising ideals which, until familiarity has dispersed the glow of romance, will seem to make the world itself a dreamland.

CHAPTER VI.

INVENTION AND MURDER.

Secret Poisoning amongst the Ancient Civilised Races—The Nature of Early Poisons—The Poisoners of Imperial Rome—Locusta's Deadly Preparations—The Mineral Poisons of the Middle Ages—Other Mediums of Despatch—Professional Poisoners—A Secret Society of Women Poisoners—La Spara—Tophania—"Manna of St. Nicholas of Barri"—The Marchioness de Brinvilliers—Tragic Death of Sainte Croix—The *Chambre Ardente* of Louis XIV. — Madame Ursinus—Lady Scott of Thirlestane's Adder Powder—A Strange Vengeance—Modern Poisoners—The Detection that now awaits the Poisoner.

THE art of invention has been largely employed for murderous purposes, the secret poisoner having in all ages exercised his ingenuity in the discovery and production of agents for the destruction of human life. Secret poisoning was an art that was practised not only by the ancient civilised races of Egypt, Greece, and Rome, but by the savage tribes of primitive nations, and although there is a good deal of fable in the stories which have come down to us from remote history, the ancients were probably skilled in the use of poisons which are unknown at the present day. The herbs of the field yielded the principal portion of their poisons; hemlock, poppy, and aconite contributing their subtle distillations; while chief amongst the animal poisons was an acrid juice secreted by a species of mollusc, called the sea-hare, the *Aplysia depilans* of Linnæus, though this decoction so readily betrayed itself that it was rarely resorted to, except by persons whose rank or position screened them from punishment.

According to Plutarch, Quintilian, and other writers, a slow poison was known which produced a gradual illness, with symptoms similar to those of consumption, the victim pining away to death, painlessly yet surely, without the slightest suspicion of foul play being aroused. This poison, which was prepared from aconite, was capable of being moderated so as to complete its work in two, three, six, or twelve months, or longer, as might be desired. Thrasyas, it is said, discovered a method of extracting from other plants a poison of even a more potent power, and his disciple, Alexias, carried the art still further. These poisons were much used by the Romans about two hundred years before the Christian era. It is related that upwards of a hundred and fifty ladies, members of Roman families of distinction, were punished at this period for preparing and administering poison. Indeed, the instances of poisoning by, and of, illustrious personages, form no small portion of the historical narrative of ancient Rome, the poisoned draught being often resorted to when bolder methods of despatch did not commend themselves.

What a terrible record of treachery stands against these people of the olden time! Drusus was the victim of a poison administered by order of Sejanus; Claudius was poisoned at the instigation of his wife, Agrippina, who employed an infamous woman named Locusta to prepare the deadly draught, which was given to the emperor in a dish of mushrooms; and the same ministress of evil, at the command of Nero, provided the potion which removed from his path Britannicus, the son of Claudius and Messalina, whom his father had named as his successor. Locusta carried on her secret work during the reigns of Caligula, Claudius, and Nero, and after being condemned to death by one emperor, was pardoned by another in order that she might be retained in the imperial service as a sort of State poisoner. Falling under Nero's displeasure for having prepared too mild a draught for Britannicus, she made atonement and saved her life by contriving a dose so powerful that the victim died the moment he tasted it. For this service Nero rewarded Locusta liberally, and gave her pupils to instruct in her secrets, so that the art, which she had studied to such fatal purpose, might not die with her.

Strange tales of secret poisoning belong to the Middle Ages, when mineral poisons, which seem to have been unknown to the ancients, were first brought into play. Many other mediums of despatch than the poisoned drink were now open to the murderer. Clement the Seventh was believed to have died of the fumes of a poisoned torch carried before him in pontifical procession; and, according to Linnæus, both the Emperor Henry IV. and a Duke of Savoy died from the odour of poisoned gloves. There is as little direct evidence on these matters, however, as of the destruction of Antony by a poisoned flower, which, as tradition has it, Cleopatra sent as a token to her lover. Still more subtle must have been the poison which Scaliger says the Turks imparted to the saddles of their private foes, ensuring them of a speedy ride to death. We are on much more certain ground when we touch upon the poisons used by the aborigines of various countries for the removal of their enemies, their poisons comprising not only the venom which renders the tips of their arrows so deadly in their effect, but those of a more insidious nature which lead the victim to death by an almost imperceptible gradation.

Coming down to the sixteenth century, we find an abundance of fairly reliable record concerning the crimes of the secret poisoners, whose mysterious plottings shed such a lurid light upon the narrative of the period. It has been the task of some recent historians to purge the memory of the Borgias from many of the charges which have been placed to their account; for all that, sufficient remains unobliterated to keep them still amongst the foremost poisoners of their epoch. After the Borgias came a succession of professional poisoners who carried their art into private family circles. Hitherto, the poisoner had been, for the most part, a secret agent of State, employed by potentates and statesmen for hastening the projects of their ambition; now, however, the genius of invention had asserted itself in this field of crime, and discoveries had been made by unknown people which rendered detection far more difficult than it had been before, and placed the fatal phial within the reach of all who could keep the secret and pay the price.

Singular to say, nearly all the great poisoners of the sixteenth and seventeenth centuries were women. In 1659, during the pontificate of Alexander VII., it was discovered that a secret society of young wives existed, some of whom belonged to the first families of Rome. They had for their rendezvous the house of a reputed witch and fortune-teller, named Hieronyma Spara. It was noticed that these wives were not happy in their conjugal relations, and that La Spara's predictions of the early deaths of first one and then another of their husbands were invariably fulfilled.

Suspicions being aroused, the government secured the services of a female spy, who, representing herself to be a member of a noble family, and affecting great distress concerning the unfaithfulness of her husband, was at once admitted into the mysteries of the order, and became possessed of a few drops of a magic liquid, innocent of colour, taste, or smell, which was supposed to enable her to settle her account with her husband for ever. On this information the government promptly acted, and La Spara and the members of her society were arrested and put to the torture. The hardened old hag herself passed the ordeal of the rack without confession, but another woman, La Gratioso, yielded up the secrets of the sisterhood rather than undergo the punishment, and she, La Spara, and three other women, were hanged together in Rome. Nine more husband poisoners suffered the extreme penalty a few months afterwards, and many women, guilty in a lesser degree, were publicly whipped through the streets of the Eternal City.

Equally notorious, and far more destructive in her operations, was a woman named Tophania, a native of Palermo, who, in that city, and subsequently in Naples, sold a mysterious poison of her own concoction to wives plagued with obnoxious husbands. Four drops of this preparation were sufficient to give a spouse his quietus, and so extensively was it sold, that it was known throughout the country as *aqua Tophania*, or *aquetta di Napoli.* We are asked to believe that this creature of wickedness carried on her nefarious trade from her girlhood until nearly seventy years of age, without ever having once fallen within the meshes of the law, and that upwards of six hundred persons were poisoned through her instrumentality. No doubt there was great laxity in the administration of justice in Italy in those days, and there were means of criminal protection and sanctuary which do not exist in our time, but it is difficult to believe that she could have escaped so long had her guilt been so commonly known as has been represented; still, even stripped of the exaggerations which we may assume were given to the story by the popular tongue, we are left with a chronicle of crime that in point of blackness is unparalleled. Tophania was more artful than La Spara, and knew better than to surround herself with a society of women, any one of whom might, in a moment of weakness, betray her. She acted with extreme caution, and dealt only with individuals, after due safeguards had been built up; and changed her abode so frequently, and adopted so many disguises, that her detection was rendered very difficult. She also called in the aids of religion and superstition. Her *aquetta* she sent forth in small phials labelled "Manna of St. Nicholas of Barri," and those who were uninitiated in the mystery of the potent elixir, imagined it to be a certain miraculous oil, which was supposed to ooze from the tomb of the saint in question, and to possess properties of universal recuperation. When, at last, the manufacture and sale of poison were traced home to Tophania, and the authorities made a determined effort to procure her arrest, she took refuge in a convent, and here she remained a considerable time, the abbess, with the sanction of the archbishop of the diocese, refusing to give her up. The Viceroy of Naples continued from time to time to demand that the poisoner should be handed over to justice, but on every occasion the ecclesiastical authorities declined to accede to his request. In the long run, the Viceroy lost all patience, and, with the assistance of a troop of soldiers, the nunnery was broken into, and Tophania was hurried off to prison. In vain did the archbishop anathematise, and the priests endeavour to invoke popular indignation on behalf of the miserable woman; the report that she had poisoned all the wells of the city turned the tide of feeling in favour of the Viceroy's action, and Tophania was without more ado put to the torture. A full confession of her crimes was extorted, and she was strangled, her dead body being thrown into the garden of the convent from which she had been taken, as a certain measure of concession to the demands of the clergy.

The case of the Marchioness de Brinvilliers belongs to the same period, and, often as the story has been told, we can hardly afford to pass it over in an account of the doings of secret poisoners. This singular woman, daughter of Dreux d'Aubray, was married in 1651, while very young, to the Marquis de Brinvilliers. The marquis, soon after the marriage, made the acquaintance of a young officer named Godin de Sainte Croix, a clever and unscrupulous adventurer, whom he invited to his house. Sainte Croix and the marchioness, who was a woman of great personal attraction, became very friendly, and together they speedily helped the marquis to the end of his fortune. Presently, the marquis died, and the conduct of Sainte Croix and the marchioness grew so offensive to her father, that he had the young officer arrested on a *lettre de cachet* and thrown into the Bastille. While in prison, Sainte Croix got into friendly communication with an

Italian, named Exili, who taught him the art of preparing poison. On gaining his liberty, after a year's incarceration, Sainte Croix instructed the marchioness in the secret work, and she immediately began to turn her knowledge to account. Disguised as a nun, she tested the poisons, which she and her lover prepared, upon the sick people in the hospitals, whom she attended in pretended charity. Satisfied of the efficacy of the poison, she then set herself to put it into operation for the improvement of her own and her companion's fortunes. Sainte Croix's servant, La Chaussée, was won over, and induced to administer the new mixture, first to her father, and then to her brother. Both died, and the same fate was intended for the marchioness's sister, but, for some unrevealed reason, the poison did not take effect. Further mischief was averted by the sudden death of Sainte Croix, and the consequent disclosure of his secrets. While preparing a quantity of poison in his laboratory, a glass mask which he wore fell off, and the fumes of the poison got to him and suffocated him. There was discovered amongst his effects a small casket, upon which was an inscription requesting that it should be delivered into the hands of the Marchioness de Brinvilliers, and stating that everything it contained concerned her, and belonged to her alone. Of course, the casket was opened by the authorities, and it was found to contain a variety of poisons with labels attached setting forth their degrees of efficacy. The marchioness fled from the country, taking up her residence in England for a while, and afterwards seeking refuge in a convent at Liége. Meanwhile, La Chaussée had been arrested on suspicion of complicity in the acts of Sainte Croix, and after full confession, strongly implicating the marchioness, he was broken alive on the wheel in 1673. The country had become so alarmed at the spread of this class of crime, that the French authorities did not dare to let the matter slumber at this point, but were resolved, if possible, to bring the marchioness to justice. With this view, an officer named Desgrais was commissioned to effect the capture of the lady, and repaired to Liége. He was not long in obtaining an interview with the murderess. Disguised as an abbé, he was admitted to the convent, and on pretence of making love to her, prevailed upon her to meet him outside the walls, and there arrested her and took her off to Paris. A written confession of her crimes, exceeding in enormity anything that had been conjectured, was found amongst her effects in the convent, and on this she was convicted and executed, being first beheaded and then burnt.

The trade of poisoning was still carried on with unabated vigour. So common did the crime become in France, that Louis XIV. established the *Chambre Ardente* for the special function of dealing with poisoners. Amongst the first offenders brought before this tribunal were two women named Lavoisin and Lavigoreux, worthy followers of Spara and Tophania, who were supposed to have sold poison to large numbers of people, and caused hundreds of deaths. The circumstances were very similar to those which had been disclosed in the cases of their Italian prototypes. They were both burned alive on the 22nd of February, 1680, their hands having been previously bored through with a red-hot iron and cut off. Many accomplices of this couple were also discovered. amongst them several distinguished people;

and from thirty to fifty persons, chiefly women, were afterwards hanged for their connection with these preparers of poisons.

Germany also produced its female poisoners, the widow Zwanziger and Mrs. Gottfried being amongst the most notable examples. They, too, with their cunning concoctions, helped their sisters to the sure dissolution of the marriage tie, and mixed the opiate of repose for scores of unsuspecting husbands. These domestic tigresses flourished for many years, and grew rich upon the fees their clients so cheerfully paid ; but detection came upon them in the end, and they expiated their crimes on the scaffold. Another follower of the Marchioness de Brinvilliers appeared in Germany in the eighteenth century—Madame Ursinus, the widow of a Berlin privy-councillor. This lady, who was a person of fashion, a writer of tracts, and a poetess, was discovered to have administered a certain arsenical preparation to her confidential servant, Benjamin Klein. She pleaded that she had merely been experimenting upon Klein for the purpose of arriving at a knowledge of what would suffice for the extinction of her own life, with the hollow gaiety of which she professed to be disgusted. The plea was accepted, and she was set at liberty. It was then remembered against her that her aged husband, her young lover, and her aunt, had all died very suddenly while she had been in attendance upon them, and the bodies were disinterred and examined ; but the chemical tests for poisons were at that day so little understood, that the doctors could not get beyond the declaration that the appearances were gravely suspicious. The court sentenced the handsome and wealthy widow of forty to perpetual imprisonment in the fortress of Glatz. Here, surrounded by every luxury, she remained until her seventieth year, when the royal pardon reached her; then, removing from the fortress to the city, she spent the rest of her life in a handsome house where she gave frequent costly entertainments. At one of these an amusing practical joke was played by an individual who had failed to receive an invitation. He bribed the confectioner to mix a nauseating drug with certain condiments intended for the feast. No sooner had the guests partaken of the food than they were seized with violent pains, and, imagining themselves to have been poisoned, every one rushed from the house, and the city was in a state of great alarm until the truth of the matter leaked out. She died at the age of seventy-six, and was known up to the last as "the poisoner."

England escaped the poison epidemic of the sixteenth and seventeenth centuries to a considerable extent, yet there are several cases of romantic interest recorded in its criminal and private annals, which go to show that the subject of secret poisoning was one that was by no means neglected in this country. One of the most curious and horrible instances of poisoning is related in connection with the family history of the Scotts of Thirlestane. Sir Robert's second wife was a woman of fierce passions and ungovernable jealousy, the object of her greatest hatred being her husband's eldest son by his first marriage, the heir to the inheritance. She resolved to rid herself, at all hazards, of her hated stepson, and on the occasion of the celebration of his twentieth birthday she carried her purpose into effect, aided by John Lally, the family piper. Three adders were procured, and from these Lally extracted the poisonous parts, ground them to a fine powder, and Lady Thirlestane mixed the fatal ingredient in a bottle of wine. The instant the young man tasted the draught he was taken violently ill, and died within an hour. Sir Robert traced the crime home to his wife, and although he could not be induced to deliver her up to the vengeance of the law, he did not fail to punish her in another way for her foul act. He had the young laird embalmed, and the body lay in state at Thirlestane for a year and a day, during the whole of which time open house was kept for all who chose to come, and the entire patrimony was spent in reckless feasting, Sir Robert saying that if he was deprived of the chance of giving his estate to his son while living, he would at least have the satisfaction of spending it upon him when dead. Sir Robert died soon afterwards, and his wife and her children were reduced to great poverty.

It is now known that the poisons prepared by the notorious criminals of the sixteenth and seventeenth centuries were mostly of a mineral nature, neutral salts of arsenic being the substance employed by Tophania. Sainte Croix's casket disclosed corrosive sublimate, opium, regulus of antimony, vitriol, and a large quantity of poison ready prepared, the principal ingredients of which, says Beckmann, the physicians were not able to distinguish. The succession powder, which was so extensively used in France, was at one time believed to consist of diamond dust ground exceedingly fine. Since then, however, the study of toxicology has advanced tc such an extent that there are few substances destructive of human life which are beyond scientific detection.

Mercury has been discovered in a corpse after an entombment of thirty-five years, and abundant traces of arsenic have been found in bodies that have been examined after an interment of eight years. At long intervals, instances occur of poisoning by substances less easy of detection, or presenting combinations or special features that tend to mystify the analyst for a time; but there is no modern case on record where chemical investigation has failed to show the presence, or indicate the kind of poison, where there has been any present. Strychnine, in the hands of Palmer; tartar-emetic, operated with by Dr. Pritchard; and aconitine administered by Dr. Lamson, accomplished all that their employers intended; but as soon as science stepped in the crime was in each instance exposed. Invention, as represented in scientific research, is now so well in advance of the secret poisoner, that we need never again expect a development of poison epidemics such as kept the social life of the seventeenth century in such a condition of terror and mistrust.

"See!" said the Marchioness de Brinvilliers to her maid one evening, holding up a little box, "I keep here my vengeance on my enemies; small as the casket is, it is full of rich inheritances!"

CHAPTER VII.

CASTLES IN THE AIR.

The Aëronautics of Mythology — Flying Machines — The Marquis of Worcester's Experiments in the Art of Flying—First Ideas of Ballooning—Dr. Black's Experiments with Hydrogen Gas—The Brothers Montgolfier and their "Fire-balloon"—A Royal Balloon—The First Ascent by Human Beings—Illustrious Aëronauts—The First Ascent in England by Lunardi—"Balloonation" a Fashionable Pastime——Lady Aëronauts—M. Garnerin invents the Parachute—The Disaster to Mr. Cocking—Scientific Results of Ballooning—Later English Aëronauts—The Balloon as an Adjunct of War—Hewson's Aëronaut Steam-engine—Captain Renard's Steering Apparatus—The Future of Ballooning.

A MODERN author, in writing what he is pleased to call "an historical romance of the future," fixes the birthplace of his hero in a balloon upon an iceberg near the North Pole, makes him live his life in a balloon, and stirs his heart to generous emotion with the poetry of balloons. He sings:

"Balloon! Balloon! Balloon!
Tell us of what the stars are made;
What are their children like?
We 're always told they 're as good as gold,
And never sulk or strike.
But aren't they often giddy found,
With always rolling round and round?"

Ever since the world began, poets, philosophers, and inventors, have been building similar castles in the air, for although the balloon itself is but a comparatively modern invention, notions of flying machines have engaged the imagination of man from the very beginning of things. Even the aëronautics of mythology are not to be carelessly set aside as meaningless myths. Phaeton's fall from his chariot in mid-air into the Eridanus; the descent of Icarus from the skies into the sea to which he gave his name; the story of the aërial soarings of Dædalus; the romantic legend of Helle and her attempted voyage through ether from Bœotia to Colchis, when, after clinging as long as possible to her brother Phryx, mounted on a magic ram, she tumbled headlong into the sea, which thenceforward became famous as the Hellespont; the throwing of Bellerophon from the winged Pegasus just as he was flattering himself that he was attaining the summit of the heavens; the adventures with the flying chariot of Medea, and the car volant of Armida; all these instances of the aërostation of the age of fable may be accepted as typical of the human strivings after volitation in the prehistoric period. Failure was written on every page of the record, and failure it continued to be, with nearly all aërial experiments, for centuries after the light of tangible fact had begun to be shed upon the exciting story. Day-dreamers were for ever realising in fancy the feelings of Hecate:

> "Oh, what a dainty pleasure 'tis
> To sail in the air;"

but they never succeeded in tasting this joy.

Archytas, who flourished four hundred years before the Christian era, and invented the screw and the pulley, is the first real name that occurs in the history of aëronautic experiment. He is said to have amused himself and astonished his neighbours by the invention of a wooden dove which was capable of sustaining itself in the air for a long period. In the reign of the Emperor Nero, Suetonius relates, Simon Magus met his death in an attempt to fly from one house to another. And so from century to century this idea of man successfully imitating the motions of a bird continued to prevail, and many machines were devised in support of the theory, much as it was ridiculed. Shakespeare had his laugh of derision at it. He wrote:

"Why, what a peevish fool that was of Crete,
That taught his son the office of a fowl;
And yet for all his wings the fool was drowned!"

In the thirteenth century, Roger Bacon employed his vigorous mind in thinking out a system of flying by artificial wings, but it came to nothing; and about the same period a citizen of Bologna contrived an apparatus by which he was enabled to fly from the mountain of Bologna to the river Reno, though his ingenuity cost him his life, for the officers of the Holy Inquisition concluded that his aërial achievement proved him to be in league with Satan, and the poor fellow was burnt alive in the cause of Christianity! In the latter part of the fifteenth century, a mathematician of Perugia rose above Lake Thrasimene by means of a mechanism of wings attached to his body.

As the science of chemistry came to be better understood, it was suggested that this was the direction in which a motive power had to be looked for, and it was on these lines that Friar Bacon, Bishop Wilkins, and others, carried forward their investigations. In his quaintly ingenious "Century of Inventions," the Marquis of Worcester, who anticipated in idea, if not in practical working, many of the great inventions of our own time, gives instructions "How to make a man to fly," and in order to prove to the reader that he is not advising what cannot really be performed, he adds, "which I have tried with a little boy ten years old, in a barn, on an hay mow." The Marquis was too wise a man to incur great risks. Milton, in his "History of Britain," mentions a monk of Malmesbury who had been a "flying man" in his youth, and whose failure to soar was attributed to his having forgotten to wear a broad tail of feathers. The Marquis de Bacqueville invented a machine with wings in 1742, and proposed to fly from the top of his own house, on the Quai des Théatins, in Paris, to the gardens of the Tuileries; but the apparatus broke down while he was crossing the Seine, and he fell against a laundry boat and fractured his leg. Fleyder, and the Jesuit Lana, also accomplished certain feats of flying.

It was not, however, until towards the end of the last century that any practical solution of the problem of floating in the air seemed to come within attainable limits. A knowledge of the nature and property of gases led many men simultaneously to devote their minds to the question; and in 1767 Dr. Black, of Edinburgh, made the proposition to fill a large skin with hydrogen gas, and demonstrated the fact that a vessel so inflated would rise into the air without any mechanical contrivance whatever. In 1783 the Brothers Montgolfier put all previous efforts at aërial transition into the shade by their discovery of the principle of the "fire-balloon," as it was called, which they immediately proceeded to put into effect. On the 5th of June in that year their first balloon was despatched to the skies at Annonay, where they carried on the business of paper-makers. News of the discovery reached the ears of the King, and his

Majesty invited the brothers to make a grand public experiment at Versailles, in the Great Court of Ministers, and there, on the 19th of September, 1783, in presence of the King, the Queen, and members of the court, a brilliant gathering of military, and 130,000 other spectators, a balloon was launched into the air. It was made of blue silk, and was forty-eight feet in diameter. The heat was applied by means of burning straw and wool, to which the King applied the match. It took some ten minutes to inflate the balloon, and then the sausage-shaped machine, with all its painted intertwinings of royal L's, rose into the sky amidst the firing of cannon and the enthusiastic shouts of the multitude, carrying with it as freight a sheep, a cock, a duck, some hay, and a barometer. The balloon rose rapidly to a considerable altitude, and in twenty-five seconds had travelled a full half-league from the palace of Versailles. While the great crowd was still watching, spell-bound, the balloon was suddenly observed to come to grief; a weak place in the silk had given way, through which the heated air rapidly rushed, and there was a speedy collapse of the aërial messenger. It fell amongst the trees that bordered the road leading from Vaucresson to Carlfour Maréchal, but its descent was so gradual that the sheep, the cock, and the duck, came to the ground unharmed, except for the chanticleer, which had its beak broken.

The balloon was now an established fact. A flying machine that would travel through the air had at last been discovered. But could any one be found willing to risk his life in making an ascent in this marvellous machine? The answer was not long in coming. Two Frenchmen quickly volunteered to brave the dangers of a voyage in the new air-ship. These were M. Pilâtre de Rosier and the Marquis d'Arlandes, who, on the 21st October, 1783, made a trip through the air together in a Montgolfier balloon, they being the first human beings to make an actual ascent. These brave explorers of the upper air took leave of Mother Earth in the presence of a vast concourse of people, royalty again looking on in its patronising way; and although the fire that they carried with them several times threatened them with destruction, they eventually returned to the ground in safety. Dr. Black's idea of inflation by means of hydrogen gas, however, was all this time working its way into acceptance. A balloon constructed on this principle had already been tested, on the 27th of August, 1783, by M. Charles, and had made its way alone, from the Champ de Mars into space, amid the approving plaudits of the leading scientific Frenchmen of the time. "It is an infant," Franklin had remarked in reference to this new aërostation; "but it will grow." It did grow, and rapidly now. M. Charles was not long in putting the theory which he favoured to a more practical test. He, in company with M. Robert, ascended from the gardens of the Tuileries on the 15th of December, 1783, in a balloon filled with hydrogen gas. Six hundred thousand spectators cheered the aërial voyagers on their way aloft, and after a pleasant trip of two hours they made a safe descent some nine leagues distant from Paris.

The new science was eagerly taken up by men of daring and ability in all parts of the world. In America, a gentleman of Philadelphia, named Wilcox, was the first to illustrate the power of the flying-ship to the astonished citizens of the new Republic. In

1784, no fewer than fifty-two separate ascents were made in balloons in various parts of Europe. Montgolfier himself ventured into cloudland at Lyons; the Duc de Chartres (Philippe Égalité) went up at St. Cloud, Guyton de Morveau at Dijon, and Prince Charles de Lignes at Lyons. A Scotsman named Tytler left Edinburgh in a balloon in the August of that year, and on the 15th of the following month Lunardi made the first ascent in England from the Artillery Ground in Finsbury, London.

Lunardi was an adventurous Italian attached to the Neapolitan embassy, who turned to "balloonation," as it was called, with the smallest possible amount of sympathy with the scientific side of the subject, and the largest possible interest in its pecuniary aspect. He worked up the public excitement with all the ingenuity of an amusement caterer; and when the pitch of enthusiasm had been reached, he chose his opportunity of launching himself, charging a guinea a head admission to the enclosure. He went up, and he came down again, and that is about all that need be said for him, except that he took with him for companions a dog, a cat, and a pigeon, and that he subsequently turned the curiosity of the public to profitable account by exhibiting himself, his animals, and paraphernalia at the Pantheon. The public flocked to the exhibition, and willingly paid him the shilling per individual that he demanded. The Neapolitan realised from £3,000 to £4,000 by the move, and, like the cautious man that he was, invested the amount in Government stocks. Lunardi cared nothing for the sneers of the *savants* so long as he made his little fortune out of the people of fashion, to whom he was the hero of the hour. Horace

Walpole did not think it worth while to run after him. "When I heard," he says, "how wonderfully he had soared, I concluded he had arrived within a stone's throw of the moon. Alas! he had not ascended above a mile and a half; so pitiful an ascension degraded him totally in my conceit. As there are mountains twice as high, what signifies flying if you do not rise above the top of the earth? Any one on foot may walk higher than this man-eagle." Men of more serious intent now devoted themselves to "balloonation." An Englishman named Sadler—the first Englishman, by the way, to enter the aërial field—made an ascent from Oxford within a month of Lunardi's experiment. Sadler went up again and again, achieving great distinction as an aëronaut. On one occasion he was accompanied by Mr. Windham, M.P., the ascent being made from Moulsey. Aëronauts made their appearance everywhere; "balloonation" became the fashionable pastime. Whenever an ascent was made it was witnessed by large multitudes. One, Richard Maguire, was knighted in 1785 by the Irish Lord-Lieutenant for "successfully going nowhere, and safely coming back;" this being, perhaps, the only instance of any one having derived titular distinction from going up in a balloon. Nor was this the first ascent that was made in Ireland. That honour belongs to a gentleman named Crosbie.

Up to this time, numerous as the balloon ascents had been, and great as the perils of aërial locomotion were, no fatal accident had occurred in connection with ballooning. Sad to say, the first man to sacrifice his life for the science was one of the two men who had made the first balloon ascent of all—Pilâtre de Rosier. De Rosier conceived the idea of constructing a balloon which should combine the principle of the Montgolfier with that of M. Charles's plan, and a large balloon filled with hydrogen gas was designed with a small fire-balloon beneath it; the former being intended to sustain the main portion of the weight of the machine, the latter to give the aëronaut the power of altering his specific gravity as he might find necessary, the usual expenditure of gas and ballast being thus avoided. The experiment failed. M. de Rosier and M. Romain, anxious to equal the exploit of M. Blanchard, who, with Dr. Jeffries, had crossed from Dover to Calais in a balloon, made an ascent in a balloon of this description on the 15th of June, 1785, from Boulogne, with the object of crossing the Channel; but the upper balloon became distended too much, the escaping gas came in contact with the fire below, the whole machine burst into a mass of flame, and the intrepid voyagers were precipitated to the earth, and instantaneously killed. It ought to be mentioned that the Marquis d'Arlandes, the companion of Pilâtre de Rosier in the first balloon ascent, also came to an untimely end not long afterwards. Charged with cowardice in the execution of his military duties, the disgrace so preyed upon him that he committed suicide.

Notwithstanding this and other fatalities, the balloon craze did not abate; there were always people to be found venturesome enough to face the dangers of the air. Three ascents were made in a day very often, and lady aëronauts competed with the sterner sex for the applause of the public. Madame Thièle was the first to lead her sisters the way through the skies. She made her initial voyage from Lyons in 1784. France again had the start. The first lady to go up in a balloon in this country was Mdlle. Simonet, who accomplished the feat successfully in 1785. Mrs. Sage, an Englishwoman, soon afterwards followed the example, and since then many other women have explored the ether in safety.

The parachute was invented by M. Garnerin in 1797, and for many years was the subject of considerable attention. The inventor's daughter, Eugénie, was accustomed to cut herself away from her father's balloon and descend to the ground unhurt from a great height. Garnerin himself also frequently illustrated the capabilities of the parachute, ascending in a balloon on one occasion from a spot near North Audley Street, and letting himself go with his parachute at an immense height, and alighting in a field near St. Pancras Church. Kuparinto's life was saved by the parachute. His balloon took fire at Warsaw, in 1808, when at a great altitude, and but for the parachute which he carried with him he must inevitably have perished; as it was, he descended in perfect safety. The parachute, however, has been the means of destroying far more lives than it has saved; and since the unfortunate disaster which befel Mr. Cocking, on the 24th of July, 1837, this scientific toy has not been much heard of. Mr. Cocking, who was a drawing-master from necessity, and a balloon enthusiast from desire—had invented a parachute of his own, which was thought to be a great improvement upon the parachute of Garnerin. It was the dream of poor Cocking's life to make a descent from a balloon by means of this parachute in the presence of a crowd of his admiring fellow-citizens. On paper, and with paper, he had worked out the invention to perfection, and in the end he prevailed upon Mr. Green, the most celebrated aëronaut of his time, to give him the opportunity for which he had so long craved. Accordingly, there was a grand day *fête* got up at Vauxhall Gardens for Mr. Cocking's special behoof on the date mentioned, when, it was announced, Mr. Green would make an ascent in the Royal Nassau Balloon, and Mr. Cocking would make his descent in his "entirely new parachute," which took the form of "an inverted cone, 107 feet in circumference." The great crowd assembled, the gardens were filled with fashionable visitors, all kinds of miscellaneous entertainments were provided to supplement the one chief attraction, and the whole scene was one of gaiety and animation, for the people took their pleasures lightly at Vauxhall in those days. At five o'clock that summer afternoon, Mr. Green and his Royal Nassau Balloon (so called in honour of a trip that the machine had made in the November previous from London to Weilburg, in Nassau, a distance of 500 miles in eighteen hours) ascended into the clouds, carrying with them the too-confident Cocking, the parachute being fastened to the car of the balloon by a rope, from which it could be freed on the pulling of a trigger. Up they went, Cocking joyously waving his adieus to the cheering crowd; but the cheering was not destined to be of long duration. Arrived at a great height, Cocking pulled the trigger, and, if all had gone well, the next moment he would have been steadily and safely descending to the ground; but either there was some misunderstanding, or the rope got entangled; anyhow, the balloon shot up into the clouds, and the parachute and its luckless inventor fell to the earth, and the laughter gave place to shrieks of dismay. It is a sad reflection upon the manners of the time that when the friends of the dead man reached the shattered body, they found that his purse had been stolen from his pocket, his watch, snuff-box, and eye-glass had been taken, and even the cap from his head, the shoes from his feet, and the buttons from his dress.

Returning to the history of the balloon proper, there is not much to tell, beyond a succession of adventures and accidents, until we come down to very recent times. Many striking incidents could be related in connection with the exploits and hair-breadth escapes, the accidents by flood and field, and the sailings away into space never to return of the brave souls who have identified themselves with ballooning. Colonel Burnaby's gallant deeds of aërostation, the disappearance for ever of Mr. Powell, M.P., on the wings of the wind, and the misfortunes that from time to time befell such well-known aëronauts as Sadler, Green, the Godards, Tissandier, Coxwell, are matters of aëronautic history which will always be borne in remembrance.

As a science, aërostation has made but little progress; as an amusement it has continued to provide diversion to the people and pleasure and profit to such as have followed it as a profession. Montgolfier believed that the balloon might become an agent of practical utility. He said: "Large balloons might be employed for victualling a besieged town, for raising wrecked vessels, perhaps even for voyages, and certainly in particular cases for observations of different kinds; for reconnoitring the position of an army or the course of vessels at twenty-five or even thirty leagues distant." It was not, however, until 1803 that any direct scientific results were attempted to be obtained from ballooning. In that year Messrs.

Robertson and Lhoëst made an ascent from Hamburg at the expense of the Russian Government, and made several meteorological experiments during a voyage extending over five and a half hours of time and seventy-five miles of distance. Other scientific explorers in regions of air about this time were Herr Sacharoff, M. Biot, and M. Gay-Lussac. The latter gentleman reached an altitude of 23,000 feet, the highest point up to that time.

In 1843, and several subsequent years, the British Association appointed a committee, and voted a sum of money, for balloon experiments, but it was not until Mr. Glaisher, in company with Mr. Coxwell, made their determined efforts to scale the skies that much tangible scientific result was obtained. In 1862 this daring pair of voyagers, in an ascent made from Wolverhampton, reached an altitude of seven miles, the highest point ever touched by any balloon traveller, when Mr. Glaisher became insensible and Mr. Coxwell very nearly so. To the science of meteorology, the balloon has, indeed, been of great service, but in regard to the science of practical ballooning itself there has been much more of promise than of actual performance. The veteran Green, the hero of fourteen hundred ascents, introduced coal-gas for purposes of inflation, and this description of gas has continued to be used ever since; it is not quite so buoyant as hydrogen, but more economical.

In recent wars the balloon has played an important part, there being now an aëronautic department in all military services. In the Civil War in America, the Franco-German War of 1870-71, and in the smaller wars in which England has been engaged of late years, military operations have been greatly aided by the practice of balloon scouting. During the siege of Paris, the balloon not only provided a few people with the means of escape from the beleaguered city, but enabled an aërial postal service to be established, by which micro-photographic letters and despatches were conveyed over the heads of the enemy into friendly quarters where they were assured of faithful dispersion to their indicated destinations. It is in connection with war, indeed, that the balloon has been most prominently utilised.

The whole question of its general utility is centred in the problem of navigation. Let it once be established beyond doubt that a balloon can be steered like a ship, in the face of contrary winds, and a field of romance is instantly opened up which will leave far behind the stories of Fortunatus and his magic carpet, and that famous hero of the Arabian Nights whose wooden horse transported him whither he pleased through the heavens. Hundreds of inventors have toiled away at this problem during the century of history which the balloon has just completed, and every few years the world has been startled with some new hope in this direction, as it is to-day. A volume might be written on the eccentric mechanical contrivances by which inventors at various periods have imagined they could save balloons from the mercy of the winds. Some apparatus have been constructed to imitate the movements of birds, some those of fishes; fans, springs, screws, wings, wheels, and sails have been brought into service; and companies have been formed for the purpose of floating machines which were lucky enough to get others beside their inventors to believe in them. In 1843 a bill was brought into Parliament to authorise the transfer to a company of a patent taken out by Mr. Hewson for an aëronaut steam-engine, but the project, though it attracted much attention at the time, and was favoured by several scientific men, fell to the ground, as the machine itself would assuredly have done had it ever been tried, for it was supposed it would be able to cleave the clouds and obey the will of the aëronaut with a weight of engine of 3,000 lbs. America sent to the Great Exhibition of 1851 a flying ship with copper boilers and engines of twelve horse-power; a Parisian tradesman named Petin built a steering apparatus, seventy yards long by ten wide, which he proposed to connect with three balloons at once; and a Mr. Luntley projected a steam-propelled machine of the weight of twenty-seven tons, which would indeed have constituted a castle in the air if it had ever got afloat. The history of modern invention is studded all over with aërial notions which have now passed into the limbo of forgotten things.

Ingenuity is, however, far from being exhausted in the contriving of methods of guiding balloons. Directive control would almost appear to have been obtained by the invention of Captain Renard, who has charge of the military ballooning department of the French army. Into the details of this invention it is needless here to enter. Suffice it that numerous voyages have been made by M. Renard in his cylinder-shaped machine, and nearly every time he has been able to bring himself back to the point from which he started. Having got so far, it is not too much to hope that navigable air-ships will at no distant day be a visible and ever present reality. As to the motive power, electricity will most likely supply that.

CHAPTER VIII.

INVENTORS IN LOVE.

Inventors give their Love to their Inventions—Arkwright's Wife—Palissy denounced by his Wife—Sir Humphry Davy and the Fascinating Widow—Lilly and the Vixen "of the temper of Mars"—Sir Samuel Morland tricked into Marriage—Quentin Matsys inspired by Love—Benvenuto Cellini and the Duchess d'Estampes—His Marriage at Sixty—The Marquis of Worcester, James Watt, Crompton, and Brindley and their Happy Marriages—George Stephenson's Three Proposals in One Year—His Three Wives—Robert Stephenson's Marriage—Nasmyth's Love Romance.

INVENTORS do not, as a rule, make good lovers. The man whose brain is full of some great mechanical project, whose heart and soul are centred on the achievement of some wonder of wheels or pulleys, or fire or steam, has not much room for the softer feelings which supply so much of the poetry of common humanity. His love is given to his invention. Of it he dreams by day as well as by night; for it he makes his sacrifices, undergoes privations, and waits and labours with such patient endurance. He will often woo and marry, after the manner of men, but he will never become the "moonstruck," love-lorn individual which more purposeless men are capable of becoming. He will be a business-like, rather than an ardent, lover; and will make a dutiful, rather than an affectionate, husband; the romance of his life is his life's work, his invention, and as that goes well or ill so will his heart be light or heavy.

Some inventors have been far from happy in their loves. Arkwright had but a sorry time of it with that spirited "Lancashire lass," his second wife, who smashed the model of his spinning frame one day in a fit of temper, because she deemed it (and perhaps not altogether unjustly) responsible for their poverty. What she thought of it all when, after separating from him, he accumulated a large fortune and allowed her £30 a year out of it, the annals of cotton-spinning do not inform us. We are told, however, that she never spoke ill of him, and would not permit any one else to do so in her hearing.

Bernard Palissy complained bitterly of the impatience of his wife under the long trials of his experiments in enamels. "Even those from whom solace was due," he said, "ran crying through the town that I was burning my floors, so that I was regarded as a madman." Sir Humphry Davy, the inventor of the Davy lamp, found love something of a delusion, if not a snare. Writing to his mother, he said, "I am the happiest of men in the hope of a union with a woman equally distinguished for virtues, talents, and accomplishments." And in a letter to his brother he expresses his rapture thus: "Mrs. Apprece has consented to marry me, and when the event takes place, I shall not envy kings, princes, or potentates." The widow must have been a person possessed of great powers of fascination, for Sir Henry Holland makes mention of her as a lady who made such a sensation in Edinburgh society that even a regius professor did not think it beneath his scholarship to go down on his knees in the street to fasten her shoe. The sequel need not be dwelt upon further than to add that the marriage turned out to be altogether a mistake. Lilly, the astrologer and alchemist, could not see for himself sufficiently far into that future, which he professed to be able to scan so clearly for others, to guard him against making a fool of himself by marrying. He caught a vixen, "of the temper of Mars," to use his own words, and the fact that she brought him £500 as dowry did not count for much in the way of compensation, seeing that "she and her relations cost him £1,000."

But this was a trifling error of perception compared with that committed by Sir Samuel Morland, who, besides being secretary to Lord Thurlow and master of mechanics to Charles II., invented a speaking trumpet and other ingenious articles. Writing when smarting under the pain of heartless deception, he says: "About three weeks or a month since, being in very great perplexities, and almost distracted for want of money, my private creditors tormenting me from morning till night, and some of them threatening me with a prison, there came a certain person to me, whom I had relieved in a starving condition, and for whom I had done a thousand kindnesses, who pretended in gratitude to help me to a wife, who was a very virtuous, pious, and sweet-dispositioned lady, and an heiress who had £500 per annum in land of inheritance and £4,000 in ready money, with the interest since nine years, besides a mortgage upon £300 per annum more, with plate, jewels, etc. The devil himself could not contrive more probable circumstances than were laid before me; and when I had often a mind to inquire into the truth, I had no power, believing, for certain reasons, that there were some charms or witchcraft used upon me, and withal, believing for certain it utterly impossible that a person so obliged should be guilty of so black a deed as to betray one in so barbarous a manner. Besides that

I really believed it a blessing from heaven for my charity to that person, and I was, about a fortnight since, led as a fool to the stocks, and married a coachman's daughter not worth a shilling; and thus I am both absolutely ruined in my fortune and reputation, and must become a derision to all the world." Sir Samuel, however, was too clever a man to allow himself to be kept down by such unholy fetters as these; besides, he lived in an age when the obligations of matrimony were at best but lightly regarded; so he survived the humiliation that his marriage brought upon him, and managed to forget the coachman's daughter in the courtly atmosphere in which he so long moved.

It is pleasant to turn from a picture like the foregoing to one of the few stories in which it is clearly shown that the passion of love has had a real influence in advancing the interests of the inventor.

On the tomb of Quentin Matsys, erected a hundred years after his death in the cathedral of Antwerp, are inscribed in letters of gold the words: "*Connubialis amor de Mulcibre fecit Apellem.*" [" Connubial love made him an Apelles."] It was, indeed, his pure love for a beautiful woman that was the inspiration of all his greatness. The "blacksmith of Antwerp," as he came to be styled, was born in poor circumstances in the year 1466, and for a long time supported himself and his mother by working as a locksmith. It was while labouring in this humble capacity that he fell in love with the daughter of a painter of Antwerp. The difference in their stations seemed at first an insurmountable obstacle to the success of his suit, but the ardour of his passion made him eloquent, and the comeliness of his person made him attractive, and he in the end won the heart of the young lady, and they might have been united had his rank in life been equal to hers. As it was, the painter declared that no one but an artist should have the hand of his daughter, and had already in his mind set apart a certain youth of birth and parts, one of his own pupils, for the honour. Even the damsel, prepossessed as she was in favour of Quentin, could not think of marrying a common blacksmith, so with some insight doubtless into the young man's natural powers, she told him that his suit was hopeless unless he could transform himself from a blacksmith into an artist, and excel the rival whom her father favoured.

It was this that made an artist of Quentin Matsys. From locks and bars he turned himself, first of all, to decorative iron-work, and constructed for the well of the great church of Antwerp, and for the College of Louvain, specimens of such work, which gained him great praise for the remarkable delicacy of execution and chasteness of ornamentation which they displayed. His next task was to make a series of exquisitely modelled images of the saints for distribution amongst the people on the occasion of a festival of the Roman Catholic Church, and so much were these admired that they increased his fame considerably. Still, this was not sufficient for the proud painter whose daughter Quentin loved with such an ardent devotion; Quentin was only a worker in iron after all. The "blacksmith of Antwerp" did not despair, however, for, though he was in delicate health, and as yet did not see clearly what was to be done to gain the chief desire of his life, the artistic instinct was strong enough within him to give him hope. For a time, therefore, he shut himself up, and studied the art of painting with so much diligence that it was not long before he produced a work which he considered worthy of being shown to the father of the young lady with whom he was in love. He took it to him, and the father was so delighted with the painting, that he there and then withdrew all objection to the proposed marriage, and in due course Quentin Matsys and the painter's daughter became man and wife. Many of his artistic productions in iron and on canvas remain to this day in the art collections of Europe to give their testimony to the leading influence in the life of this remarkable man, the influence of a pure and simple love.

Benvenuto Cellini had adventures in plenty during his active career in various cities as a worker in metals, and had often to play the part of the gallant, for the sixteenth century was a time of intrigue and plotting, and, in the courtly scenes in which he frequently moved, it was impossible to avoid entanglement in a love episode occasionally. But the ingenious Florentine was as crafty as he was talented, and was not easily to be taken advantage of. While at Fontainebleau, making silver statues for Francis I., he fell into disfavour with the Duchess d'Estampes, and that unscrupulous favourite resolved upon his ruin. On one occasion, when Benvenuto was about to show the King a statue of Jupiter which he had just completed, the duchess contrived to have placed in the room where the statue had to be exhibited a number of the finest antique sculptures, thinking thereby to disgust the King with the inferiority of Benvenuto's work. "When I saw these wonders of art," wrote the artist, "I thought within myself, this is like passing through the pikes of the enemy. Heaven protect me from danger!" But he was a man of resource, and always quick to act, so, before the King came he managed to arrange the lights so that his own statue should be seen to the best possible advantage. "When I saw his majesty enter," he says, "I ordered my boy, Ascanio, to push the statue of Jupiter before him; and this motion being made with admirable contrivance, caused it to appear alive; so that the other figures were left somewhat behind, and the eyes of all the beholders were first struck with my performance. The King immediately cried out, 'This is one of the finest productions of art that was ever beheld; I, who take pleasure in such things, and understand them, could never have conceived a piece of work the hundredth part so beautiful.'" The success of this stroke enraged the duchess all the more against him, and she afterwards made life so unbearable to him at Fontainebleau that he was forced to leave the country. Many more strange and wonderful things happened to Benvenuto, all of which he has duly set forth in that remarkable autobiography of his, one of the most stirring romances ever written; but Cupid caught him firmly in his toils in the end, and at the age of sixty the great Florentine married, and had a family of several children.

It has been said that those who have the shortest histories lead the happiest lives. If that be so, it is plain that most of our great inventors have been very happy in their matrimonial speculations, seeing that of their wooings and marryings we hear so little. Caxton is believed to have been married, but nothing beyond a brief entry in a register of burial supplies any evidence in this direction; the Marquis of Worcester was married, and his wife believed in his inventions, for she kept many of them in working order long after his death; and James Watt was one of those who was blessed with the love of a woman who had unbounded faith in him. Watt's wife was his cousin, and when they set up housekeeping together, in the Saltmarket, Glasgow, she was a great help to him in his labours by her cheering words of encouragement. When the cloud of disappointment used to gather on his brow, as it often would in those days of struggle and poverty, she would say to him, "Don't despair; if this will not do, something else will." She died in 1773, after they had been married only nine years.

Crompton fell in love with a comely young woman of his own station because of her expertness as a spinner on Hargreaves' jenny, and when they set up house together in the little cottage attached to the "Hall i' th' Wood," she afforded him her affectionate aid in working out the models of his famous "mule." Brindley did not fall in love until he was nearly fifty. His biographer speaks of him as having "little time for friendship, and still less for courtship." But at the house of John Henshall, the land surveyor at Bent, near New Chapel, he found a young lady (Henshall's daughter Anne) whose presence was so pleasing to him that he generally took her a pocketful of gingerbread when he visited her father's house. He ultimately proposed to her and was accepted, and they were married, she being nineteen, he forty-nine. Dr. Smiles suggests that "the union may have been quite as much a matter of convenience as of love on his part." After the marriage she managed all his correspondence, and proved herself a "most clever, useful, and affectionate partner."

George Stephenson was too busy a man to have much time for love-making; he was practical in this as in other affairs, and did not go far afield for his choosing. It was while at Black Callerton, fulfilling the duties of brakesman at the Dolly pit, that the idea of marriage seems to have occurred to him as an advisable step; and as an evidence of his earnestness in the matter, when once he had made up his mind, it need only be mentioned that he made three proposals of marriage in one year. He was at that time lodging in the farmhouse of Thomas Thompson. Miss Hindmarsh, a farmer's daughter, was the first damsel he made an offer to, and she accepted him; but the farmer would not hear of it, and sent the young engineer about his business. A brakesman with about a pound a week was not considered good enough for the farmer's daughter by any one except herself, and "northern farmers" had in those days a way of enforcing obedience upon their offspring which was effective, if a little rough.

George was doubtless disappointed at being snubbed by the farmer, but he did not fret; he simply "made up" to another young lady, or rather, to two, and tackled the matter in a fair business spirit. There was a servant-girl named Fanny Henderson, living in the farmhouse in which Stephenson lodged, with whom he was on terms of friendliness. Fanny had several sisters, who visited her from time to time, and it was with one of these (sister Ann, in fact) that George next fell in love.

It was for Ann (wrote Mr. Pattison, her nephew) that George mended the shoes which Dr. Smiles refers to as having been carried about in the brakesman's pocket on the Sunday afternoon after they were finished, when George every now and then pulled them out and held them up, exclaiming, "what a capital job he had made of them." Ann Henderson was, we are told, the youngest and prettiest of the sisters; but she was not at all smitten with the amateur shoemaker and jack-of-all-trades, so George, determined to go no further in his love quest than this family circle would take him, at last proposed to the faithful and industrious Fanny, not at all held back by the fact that she was twelve years his senior. There was no "lang coortin'" to follow. After his removal to Willington Quay, to take charge of the engine on Willington Ballast Hill, at an increased wage, he, on the 28th of November, 1802, married Fanny Henderson at Newburn Church. The age of the bride was thirty-three; that of the bridegroom twenty-one. It is worthy of note that the future author of railway travelling had to be content to make the bridal journey in the most primitive of fashions. "Two farm horses," says his biographer, "borrowed from a neighbouring farmer, were each provided with a saddle and pillion, and George having mounted one, his wife seated herself behind him, holding on by his waist. The bridesman and bridesmaid in like manner mounted the other horse; and in this wise the wedding party rode across the country, passing through the old streets of Newcastle, and then by Wallsend to Willington Quay, a ride of about fifteen miles." Fanny made George an affectionate wife, and the two lived happily together for the few years of their married life. George's only son, Robert, who was destined to almost equal his father in fame, was born in October, 1803, and in 1806, shortly after giving birth to a daughter, the devoted wife died, and "George felt as one that had thenceforth to tread the journey of life alone." And for fourteen years George Stephenson remained a widower, happy in the affection of his son, and occupied year by year with increasing business responsibilities; but in 1820, when fortune was beginning to smile upon him, he again proposed for the hand of his first love, Elizabeth Hindmarsh, the farmer's daughter, and this time no objection was raised to the alliance, and the couple were married at Newburn Church on the 29th of March, 1820. There has been much written concerning George Stephenson's life from 1820 down to the period of his death in 1848; but hardly a single glimpse are we permitted to have of the domestic side of his career during those twenty-eight years.

Smiles says, speaking of Stephenson's evenings at home, when the Liverpool and Manchester line was in course of construction, "The presence of Mrs. Stephenson gave them an additional charm: amiable, kind-hearted, and intelligent, she shared quietly in the pleasure of the party; and the atmosphere of comfort which always pervaded her home, contributed in no small degree to render it a centre of cheerful, hopeful intercourse, and of earnest, honest industry. She was a wife who well deserved what she through life retained, the strong and unremitting affection of her husband." This is nearly the only reference that is made to the second Mrs. Stephenson, but perhaps it is enough. She died in 1845, and a tablet to her memory was erected in Trinity Church, Chesterfield. George Stephenson married again, in 1848, about six months before his death, the lady who had for some time been his housekeeper being promoted to the honour of being his third wife. We have it on the testimony of Mr. Starbuck, however, that she gave her husband "the most devoted and unremitting care" on his death-bed, and with that we have to be content. In his last marriage, even more than in his former marriages, he showed that he was not inclined to go far out of his way for the selection of a wife.

Robert Stephenson, when he married, stood on a different social platform from that upon which his father had stood at the time he took Fanny Henderson to wife. Robert had culture and refinement to help him, and it would not have been surprising had he experienced some romance in his love-making, considering the adventures and surprises he passed through. We only know, however, that he married the daughter of a London merchant in 1829; that she died childless in 1842; and that Robert never married again, but showed his affection for the memory of his wife by visiting her grave in Hampstead churchyard twice a year up to the time of his death.

James Nasmyth, the inventor of the steam-hammer, relates, in his autobiography, the story of his falling in love, and for once we get a touch of the romantic in an inventor's loving. After confessing that he had had "few opportunities of enjoying the society of young ladies," he goes on to say: "I had occasion to make a business journey to Sheffield on the 2nd of March, 1838, and also to attend on some affairs of a similar character at York. As soon as I had completed my engagement at Sheffield, I had to wait for more than two dreary hours in momentary expectation of the arrival of the coach that was to take me on to York. The coach had been delayed by a deep fall of snow, and was consequently late. When it arrived, I found that there was only one outside place vacant, so I mounted to my seat. It was a very dreary afternoon, and the snow was constantly falling. As we approached Barnsley, I observed, in the remaining murky light of the evening, the blaze of some iron-work furnaces near at hand. On inquiring whose works they were, I was informed that they belonged to Earl Fitzwilliam, and that they were under the management of a Mr. Hartop. The mention of his name, coupled with the sight of the ironworks, brought to my recollection a kind invitation which Mr. Hartop had given me whilst visiting my workshop in Manchester to order some machine tools, that if I ever happened to be in his neighbourhood, he would be most happy to show me anything that was interesting about the ironworks and colliery machinery under his management. I at once decided to terminate my dreary ride on the top of the coach. I descended, and, with my small valise in hand, I trudged over some trackless, snow-covered fields, and made my way by the shortest cut towards the blazing iron furnaces." He was introduced to Mr. Hartop's wife and daughter Anne. Speaking of the latter, Mr. Nasmyth says, "I soon perceived in her, most happily and attractively combined, all the conditions that I could hope for and desire to meet with in the dear partner of my existence." He proposed, and was accepted, and two years afterwards, on the 16th of June, 1840, they were married. "From that day to this," he adds, "the course of our united hearts and lives has continued to run on with steady, uninterrupted harmony and mutual happiness. Forty-two years of our married life find us the same affectionate and devoted 'cronies' that we were at the beginning, and there is every prospect that, under God's blessing, we shall continue so to the end."

It is not, however, in their loves that the great inventors have revealed the most romantic features of their lives.

CHAPTER IX.

THROUGH POVERTY AND SUFFERING.

Bernard Palissy—His Long "Wanderschaft"—The Awakening of his Ambition—His Years of Patient Experiment—Domestic Cares—Fits of Melancholy and Despair—His Ultimate Success—Court Patronage—"Bernard of the Tuileries"—He Espouses the Reformed Religion—Massacre of St. Bartholomew—Condemned to the Bastille—Henry III. visits him in Prison—Death of Palissy—Joseph Jacquard—His Early Struggles—Is left an Orphan—His first Efforts of Invention—Marriage and Poverty—The Outbreak of the Revolution—He and his Son join the Army of the Rhine—The Son killed on the Battle-field—Jacquard returns Home—More Struggles—He Invents a Fishing-Net Machine—The Prefect sends for him—Napoleon summons him to Paris—The Invention of the Jacquard Machine—His Reward—Aloys Senefelder—His Dreamy Youth—Attempts at Authorship—Resolves to Print his own Plays—His Curious Experiments—The Arrival of the Washer-woman—Lucky Way out of a Dilemma—Invention of Lithography—Success at Last—Argand and his Lamp—Poverty and Death.

THE inventor often, in his most sanguine moments of hope, seems to have all the world against him, for, however near he may be to the realisation of his dreams, it is difficult to attract to himself the faith of others, until his invention has been practically tested and been approved. The majority of our great inventors have had to struggle with poverty while they have been working out their ingenious problems, but, no matter how severely they have suffered, or how much they have incurred the scorn and neglect of their fellow men, they have for the most part persevered to the end.

The history of invention is full of such examples of brave endurance; and although the instances which we propose to give belong mostly to times antecedent to our own, it does not follow that the poor inventor has become an obsolete personage.

Few men have been more bitterly assailed by poverty, or exposed to more cruel persecution, than Bernard Palissy, in whose soul shone the light of eternal genius, in whose heart dwelt nothing but purity. "I have had no other books than heaven and earth," he said, "which are open to all." And these were nearly all sufficing for the humble peasant, for to him had been given the power and capacity to read them with a clearness and a sympathy which extended far beyond the range of scholarship. In Palissy there was the inborn enthusiasm which belongs to all true greatness, which exerts its sustaining influence in the face of trial, neglect, and oppression, and burns brightly to the last—until the master idea of existence is realised, or is hallowed in martyrdom.

Bernard Palissy was born in the diocese of Agen, in or about the year 1510, and at an early age was instructed in the art of glass-painting, which occupation he followed for many years with indifferent success in various parts of France. As he wandered from place to place, remaining a month here or a year there, he made the best use of his powers of observation, and gathered much information from the worlds of art and nature, studying the memorials of antiquity that came in his way, and acquiring that knowledge of natural history which was the outcome of his love of all created things. He also dabbled a little in chemistry, a science that was then in its infancy, and directed his attention to the study of minerals and earths. Still he did not settle down; his period of "wanderschaft" was not yet completed; the object that was to focus his active and restless mind into one supreme directness of purpose was undiscovered.

In the year 1538 he found himself in the town of Saintes, and there fell in love with and married a young woman in his own station of life, and tried his utmost to shake off his old restlessness of spirit. At Saintes he contrived to make a decent income for a while by glass-painting and land-surveying, but in 1540 he had a specimen of pottery shown to him which set him dreaming, and awoke his genius to a task worthy of its ambition. From that moment Palissy was a potter in mind, heart, and soul, and ready to sacrifice all else in life to work out his plans. It was an earthenware cup, that he had seen, probably a sample either of the Moorish pottery introduced into Italy in the twelfth century, and known as the Majolica ware, or of the works of Lucca della Robbia, who executed a great variety of ornamental works for Cosmo de Medici.

Referring to this specimen, Palissy afterwards wrote:—"There was shown me an earthen cup turned and enamelled with so much beauty, that from that time I entered into a controversy with my own thoughts, recalling to mind several suggestions that some people had made to me in Pau, where I was painting portraits. Then seeing that these were falling out of request in the country where I dwelt, and that glass-painting was also little patronised, I began to think that if I should discover how to make enamels, I could make earthen vessels and other things very prettily; because God had gifted me with some knowledge of drawing. Thereafter, regardless of the fact that I had no knowledge of clays, I began to seek for enamels, as a man gropes in the dark."

Then began that long and patient quest which, before it was ended, almost made a martyr of the zealous Palissy, and kept himself and family for many years at the point of starvation. He confesses to having "fooled away several years imprudently, with sorrow and sighs." Being ignorant of the materials of which enamels were composed, he pounded and ground "all the substances which he could suppose likely to make anything," and heated, and melted, and baked them, at such a cost of time and money as soon reduced him to great straits. Failure followed failure; at every turn he was met by disappointment; but still he persevered. Meanwhile, his family increased along with his difficulties, and want and hunger came upon them. Temporary relief was afforded after a time by his being engaged in a survey of the salt marshes of Xaintonge, consequent on the establishment of the *gabelle*, or salt tax. This continued for a year or more, and provided him with a little money to experiment with further. Then "I resumed my affection for pursuing in the track of the enamels," he says, and two more years of indomitable effort followed, during which time he made no fewer than three hundred different chemical mixtures, and broke pots without number, to the no small disgust of his family and neighbours, who regarded him as little better than a madman for his pains. His own furnaces would not give him the heat he required, nor would the potters' furnaces, so he bethought him he would send his trial pieces to the glass furnaces, and it was in watching the action of the increased heat in front of these flames that he discerned his first ray of real hope. Domestic cares weighed so heavily upon him, however, that it was with extreme difficulty he could adhere to his task; he therefore resolved upon one final effort, and if that failed he would desist from further experiment, and turn again to his old work of glass-painting, in order to earn support for his hungering family. He prepared the final pieces with hope and loving care, took them to the glass furnace, and sat in earnest silence for four long hours waiting the result. When at last the furnace was opened, and the pieces were drawn out, he saw that on one of them the material was melted, and when the piece had cooled it was coated with "a white enamel, singularly beautiful, which caused him such joy as made him think he had become a new creature."

Having found the kind of furnace he wanted, he now set about building one for himself, and, this being completed, his experiments were renewed with increased vigour and enthusiasm. But he was still by no means at the end of his troubles. He says:—"Having covered the new pieces with the said enamel, I put them into the furnace, keeping the fire still at its height; but thereupon occurred to me a new misfortune, which caused great mortification—namely, that the wood having failed me, I was forced to burn the palings which maintained the boundaries of my garden; which being burnt also, I was forced to burn the tables and the flooring of my house, to cause the melting of my second composition. I suffered an anguish that I cannot speak of, for I was quite exhausted and dried up by the heat of the furnace; it was more than a month since my shirt had been dry upon me. Further to console me, I was the object of mockery; and even those from whom solace was due, ran crying through the town that I was burning my floors; and in this way my credit was taken from me, and I was regarded as a madman."

Convinced now that the discovery he had striven after so long and ardently was an accomplished fact, and only needed means and superior skill to develop into success, he laboured on yet several years, improving and perfecting his work, in spite of the stress of poverty and the inadequacy of his materials and implements. He had a potter to help him for six months, "to whom," he says, "for want of money, I was forced to give part of my clothes for wages." His furnaces failed him time after time, and shame and confusion came upon him. He describes himself as lying down in melancholy on one occasion, when he found a batch of pieces bestrewn with little morsels of flint. "There were still some who would buy them," he says, "at a mean price; but, because that would have been decrying and abasing of my honour, I broke in pieces the entire batch from the said furnace, and lay down in melancholy—not without cause, for I had no longer any means to feed my family; I had nothing but reproaches in my house; in place of consolation they gave me maledictions. My neighbours who had heard this affair said that I was nothing but a fool, and that I might have had more than eight francs for the things that I had broken; and all this talk was brought to mingle with my grief." But the brave heart of Palissy did not falter, though the mental and physical suffering through which he passed might well have overwhelmed him. "I was for the space of ten years," he wrote, "so wasted in my person, that there was no form nor prominence of muscle on my arms or legs; also the said legs were throughout of one size, so that the garters with which I tied my stockings were at once, when I walked, down upon my heels with the stockings too. I often walked about the fields of Saintes considering my miseries and weariness, and, above all things, that in my own house I could have no peace, nor do anything that was considered good."

Success crowned his efforts at last, and he began to find a market for his "rustic pieces," dissatisfied as he often was with them, for the green of the lizards was sometimes burnt before the colour of the serpents was melted, and the colours of the serpents, lobsters, tortoises, and crabs were melted before the white had attained its full beauty. It was as a "Worker in Earth, and Inventor of Rustic Figulines," that Palissy now announced himself to the public, and his ware came under the notice of wealthy patrons of art, and at last he gained fame and profit. The Constable Montmorenci engaged him to furnish the encaustic decorations of his famous Château d'Ecouen, and he removed to Paris and set up a workshop in the neighbourhood of the Tuileries, where he became renowned as Bernard of the Tuileries, and for ten years continued to produce a succession of works of art pottery of great beauty and variety. Palissy ware was the fashion, and its inventor, now freed from his struggles with poverty, amassed wealth. But, hardly was his fight for his art fought to the point of victory, than he was compelled to fight as zealously and bravely for his faith. The potter had espoused the reformed religion, and in 1562, before he left Saintes, would inevitably have perished at the gallows, but for the friendly intervention of Montmorenci, who not only procured his release, but obtained for him the appointment of "Inventor of Rustic Figulines" to Catherine de Medici.

This protection served to shelter him from the terrors of the massacre of St. Bartholomew; and in his later years he acquired additional distinction by his philosophical and scientific attainments, delivering lectures to the learned men of his day on subjects connected with natural history. Buffon has said of him that he was "so great a naturalist as Nature only can produce." The last four years of Palissy's life were spent in prison. Henry III. gave way at last to the evil counsel of the Guise party, and issued an edict condemning all who exercised the reformed faith to death. Under this edict Palissy was committed to the Bastille, and there Henry visited him and urged him to renounce the new religion. The king told the potter that he would be compelled to order Palissy and two girls who were his fellow prisoners to death unless they recanted. Palissy returned the following characteristic answer to the monarch: "You have said several times that you feel pity for me; but it is I who pity you, who have said '*I am compelled.*' That is not speaking like a king. These girls and I, who have part in the Kingdom of Heaven, we will teach you to talk royally. The Guises, all your people, and yourself, cannot compel a potter to bow down to images of clay." Palissy died in the Bastille in 1589, the same year that Henry III. perished by the hand of the assassin.

Joseph Jacquard, who gave his name to the Jacquard loom, an invention which greatly developed the art of weaving, had a long struggle with poverty before he won any solid reward for his ingenuity. Born at Lyons in 1752, the son of a hand-weaver of brocades, he was at twelve years of age placed in a bookbinder's workshop to earn his own living. Of education he had little, and that little he had contrived to pick up himself, acquiring the art of reading and writing without the aid of a schoolmaster. From the bookbinding business he was removed to a type-caster's establishment, where he showed noticeable skill in constructing certain tools. While he was still very young his mother died, and his father took him home to assist in the weaving of brocades. A few years later the father also died, and young Jacquard was left an orphan with very scanty means. For a time he strove to follow the business of a fabricator of stuffs, and fitted up a workshop for that purpose; but misfortune continued to follow him, he got involved in debt, and was obliged to sell his looms. To make matters worse (or better), he was all this time over head and ears in love with the pretty daughter of a neighbouring gunsmith, and, as he saw himself sinking lower and lower, day by day, into the depths of poverty, the chance of ever calling her his wife seemed to grow correspondingly remote. But the young lady was made of the right stuff, and clung to him all the closer for his poverty. They married, and faced the battle of life together. Seldom have a couple fought a sterner fight than these two did through the long years that followed, during which time the husband, strong in his purpose of invention, and the wife, strong in her steadfast faith and patience, hoped and worked for better days.

But these days were slow in coming. He busied himself with designs for improvements in various kinds of machinery; but nothing practical came of them—he could get no one to take them up, and so the couple drifted into absolute penury, and he remained obscure and unknown. They were driven to such straits that his wife was compelled to support herself by straw-hat making, while he went to work as a labourer at a lime-kiln in a neighbouring village. But although he was forced to abandon for a time his mechanical pursuits, he never completely severed his thoughts from them. He treasured up dreams of great inventions which were one day to bring him reputation and wealth, and lift his noble wife from the shadow of poverty. Just as fresh hopes were springing within him, France itself was plunged into the midst of a struggle for life or death; the Revolution broke out, the passions of men were excited to their utmost tension, and the aims and dreams of individuals were lost in that mad, unreasoning scramble for liberty which, while it lasted, absorbed all human energies. Jacquard threw himself into the contest, and followed the fortunes of the Revolution with unstinted courage and ardour. He was one of the leaders of the defence of his native city when, in 1793, it was besieged by the army of the Convention; and when, after a brave resistance of sixty-six days, the citizens were compelled to surrender, and the machinery in the factories was destroyed, Jacquard was denounced, and had to fly for his life. He took with him his only son, a youth of seventeen, and the two joined the army of the Rhine. The son was mortally wounded on the battle-field, and died in his father's arms. Jacquard, stricken with despair, now made his way back to Lyons. He found his house burned to the ground, his wife gone no one knew whither. After diligent search he discovered her in the desolation of a garret, toiling for bread at her old occupation of straw-hat making. The bereaved and sorrowing couple consoled each other as best they could, and, having nothing else to fall back upon, Jacquard for a time helped his wife with her straw-platting, the two earning barely sufficient to hold body and soul together. So matters continued with but little improvement until the torrent of the Revolution had swept by, and people could turn their thoughts once again to the arts of peace.

Shortly after the signing of the Treaty of Amiens, Jacquard's attention was arrested by a newspaper paragraph in which it was stated that the English Society of Arts offered a premium to any person who could invent a machine for weaving fishing nets. This stirred the old desires within him, awakened him to new life, and set his thoughts afloat once more over the silver cloudland of invention. He was not long in contriving such a machine as was required, but as soon as it was completed he lapsed into indifference again, gave the invention to a friend, and turned to something else. The machine, however, found its way to Paris, and excited so much interest, that the authorities showed a strong desire to discover the inventor. It thus came about that one day the Prefect of Lyons sent for Jacquard and questioned him upon the subject of his net-weaving machine. At first, Jacquard did not comprehend the meaning of the Prefect; the thing had passed from his memory; but the production of a net woven by the machine recalled the whole of the circumstances to his mind, and he at once explained the apparatus to the Prefect in detail. Shortly afterwards Napoleon summoned Jacquard to Paris, and installed him in the Conservatory of Arts and Trades. Previously to this, in 1801, he had taken out a patent for a movable pedal for looms, which was intended to do away with the draw-boy, and Carnot, the Minister of the Interior, had interested himself in the invention, for which a bronze medal had been awarded. For the machine for fishing-nets he received a gold medal.

When Jacquard got to Paris he was set to work to make his machine on a much larger scale, and while so engaged had opportunities of observing all that was going on in connection with other mechanical departments. One day he was attracted by a machine that was weaving a shawl for the wife of Napoleon. "Rather an expensive job that, sir," he said to the director. "Twenty thousand francs!" "Why," exclaimed Jacquard, "in yonder corner is a machine by Vaucanson, which, with a little more attention, would answer the same purpose, and would not cost more than five hundred. It is a pity that serious attention is not paid to Vaucanson's clumsy invention, for it contains the principle of all combinations in weaving. I must look to that."

After that Jacquard applied himself to this new idea and shut himself up in his workshop until he had achieved a satisfactory result. To begin with, he constructed from memory a model of Vaucanson's machine, which he thought would be a pretty curiosity to take home to his wife; then, with the model before him, he proceeded to work out his grand notion. One morning, while hard at his task, with his sleeves tucked up to his elbows, and singing a simple Lyonnese air, he was surprised by the sudden opening of the door. The First Consul stood before him. "Well, Master Jacquard, how progresses my net machine?" "First Consul, it is completed." "But this is not the machine?" "No, sir; this is a machine for weaving silk stuffs. Vaucanson inspired me with the idea. This machine will simplify the labour of the weaver of articles of luxury, and will allow the workmen at the loom to be like other men, without making them bandy-legged and hump-backed. You little know, sir, to what contortions of body, to what fatigues, the poor creatures are subject. The head workman, seated on a high stool, is compelled to fling out his legs right and left, to give the proper direction of the threads which the pattern and fashion of the work require. One or more workmen are employed to put the cords in motion. For this task, which is torture itself, children and young girls are employed; we call them *tireuses de lacs.* The unfortunate little creatures cannot go through their occupations without forcing themselves into positions which give rise to deformities, check their growth, and sow the seeds of disease. With the blessing of God, I hope this machine will remedy all this." Napoleon took the inventor by the hand, and said: "Jacquard, you are a noble citizen." After his machine was completed he returned to Lyons with a pension of a thousand francs, which was subsequently raised to six thousand.

But, although he had perfected his invention, he had not yet done with his difficulties. The workpeople rose against him, burned his machine in the public square, and threatened his life; but, supported by the influence of a rich manufacturer, and encouraged by the Municipal Council and Chamber of Commerce of Lyons, he was at length enabled to overcome the popular prejudice, and disposed of his patent to the municipality for the public benefit, reserving for himself only a royalty of fifty francs on each machine. When Napoleon signed the necessary authority for securing this right to the inventor, he is said to have exclaimed: "Here, at least, is one who is satisfied with little!"

The Jacquard loom was adopted in the textile industries of England and America, and its inventor was loaded with honours. The manufacturers of Manchester offered him a large sum to settle amongst them, but he preferred to remain in his native country. He continued to live in Lyons until the death of his wife, who was permitted for a while to share his prosperity as she had shared his poverty; he then retired to a quiet country cottage a few miles distant from Lyons, and there ended his days in seclusion and repose in the month of August, 1834. His statue now ornaments the chief public square of his native city, and a full-length portrait of him, painted for the Corporation, adorns the Lyons Museum. The Jacquard loom, however, is the monument of his genius which will endure beyond all others; it is one of the few inventions which seem to have been thought out in a thoroughly complete form on its first projection; it opened up at a stroke, as if by magic, an indefinite field of operation for the designers of figured fabrics by a simple process; and is to-day to be counted by the hundreds of thousands, having, with its revolving cards, effectually superseded all other methods of producing fancy cloths. Jacquard might easily have made himself a millionaire by this one machine; he was content to accept a moderate competency and let the world reap the benefit of his wonderful invention.

Within a couple of months of the death of Joseph Jacquard in his rural cottage near Lyons, there died at Munich another inventor whose life had for a considerable period been one long weariness of hope deferred, who, like Jacquard, saw his invention universally adopted, and in the end reaped the advantage of his handiwork. This was Aloys Senefelder, the inventor of lithography, a sort of universal genius who could do a little of everything but few things superlatively well. He was born in 1771. His father was a comedian at the Munich Theatre, and Aloys also wanted to go on the stage, but his father would not hear of it. Aloys was something of a poet too, and something of a fiddler; he could paint a little also, and, what was better still, as it turned out, he knew just sufficient of the art of engraving to make him desirous of knowing more. His father sent him to the University of Ingolstadt to study the law, but the law was so little to his mind that he made no progress in it; preferring, rather, to write a comedy and appear in it along with a private company. The comedy was published, moreover, but does not seem to have brought him either fame or profit. Still he continued to write; he wrote operas, plays, and ballads; he also painted pictures; but it was evident that it was not in this direction that his genius, if he had any, was to be developed. When Aloys was only twenty years of age his father died, and the youth had to relinquish his attendance at the university, for the family means would not admit of any further payment of fees. He now tried in earnest to press his way on to the stage, and obtained an engagement, but he was cast for such paltry parts and received such poor pay that he soon came to the conclusion that his living would have to be earned in some other sphere.

About this time he prevailed upon a firm of printers to pass through the press another play that he had written, but they failed to keep pace with his desires, so he resolved to be his own printer by some new and inexpensive process. It was this determination that first called forth his inventive powers. He possessed himself of a small stock of type, and having set up a page, made a composition of his own for stereotyping it. This consisted of clay, fine sand, flour, and pulverised charcoal, which, when mixed with water and kneaded into a stiff paste, would take a mould from the page of type, becoming in a few minutes hard enough to admit of a cast being taken from it in melted sealing-wax. This was a great achievement to be accomplished out of such limited resources, and deserved a greater measure of success than attended it, for, after all, Aloys had to abandon his project for want of money. He then turned his attention to copper, but at every stage of his experiments an empty purse stopped the way. The coppersmith refused to let him have any more plates unless he paid for them, so he bethought him he would try to utilise the old plates by rubbing off the engravings with stones, and selected a soft, calcareous stone that he had often seen on the banks of the river Isère as being the best adapted for his purpose. This made the copper last out a while longer, but at length a point was reached when little except the stones was left, and Aloys was driven to despair. Then he tried etching on the stone itself, but aquafortis made the stone effervesce, and could not be bitten deep enough for the reception of printing-ink. A curious incident soon afterwards helped him to the solution of the problem.

"I had just succeeded," he writes, "in polishing a stone plate, which I intended to cover with etching-ground, in order to continue my exercises in writing backwards, when my mother entered the room, and desired me to write her a bill for the washerwoman, who was waiting for the linen. I happened not to have even the smallest slip of paper at hand, as my little stock of paper had been entirely exhausted by taking proof impressions from the stones; nor was there even a drop of ink in the inkstand. As the matter would not admit of delay, and we had nobody in the house to send for a supply of the deficient materials, I resolved to write the list with my ink prepared with wax, soap, and lamp-black, on the stone which I had just polished, and from which I could copy it at leisure. Some time after this, I was just going to wipe this writing from the stone, when the idea all at once struck me to try what would be the effect of such a writing with my prepared ink if I were to bite in the stone with aquafortis; and, having bitten away to about the hundredth part of an inch, I found that I could charge the lines with printing-ink, and take successive impressions. Thus the new art was invented."

Senefelder knew he had hit upon a great invention, but even now he was not permitted to turn it to immediate account. He would require a press, and a stock of paper, ink, stones, &c.; and he was without money. In this dilemma he offered to enlist in the army as a substitute for a friend who promised him a premium of 200 florins; and with this object he went with a party of recruits to Ingolstadt, but was rejected because he was not a native of Bavaria. A musician named Glaissman came to his aid at this juncture, and

SENEFELDER AND THE WASHERWOMAN'S BILL.

together they issued some pieces of music, in 1796, these being the first lithographic prints published. The elector, Charles Theodore, sent them a present of 100 florins, and the Academy of Sciences made him the munificent grant of 12 florins, with an intimation that since, according to his own statement, the expense of the press did not exceed six florins, "it was hoped that a compensation of double that amount would satisfy his expectations." Much time was spent in experimenting upon new presses, and so many failures resulted that Senefelder's invention came to be regarded in many quarters with disfavour. But Senefelder was not to be discouraged. He persevered and persevered, and at last conquered his difficulties, being joined in his business operations at different times by his two brothers, M. André, Baron Arctin, and others. He successively invented the ink, chalk, etching, transfer, and woodcut processes; introduced lithography in colours, and many other improvements in the art of his invention. He now reaped the reward of his ingenuity, and made money. A royal lithographic establishment was formed, and he was appointed to its superintendence with a salary of 1,500 florins, with liberty to carry on his private enterprises at the same time. For the rest of his life he was in comfortable circumstances; and in 1819 he published a complete disclosure of all the secrets of the various lithographic processes, esteeming himself happy in seeing during his own lifetime the value of his invention so universally appreciated. He died at Munich on the 26th of February, 1834.

Aimé Argand, the inventor of the lamp associated with his name, never fairly lifted himself out of the rut of poverty, but lived and died poor, disappointed, and neglected. He was born at Geneva in 1755, but was living in England in 1782, when his first lamp was produced. The main feature of his lamp was that the wick fitted into a hollow cylinder, up which a current of air was allowed to pass, admitting a free supply of oxygen to the interior as well as the exterior of the circular flame. This was the invention as it stood until his younger brother, by accidentally placing a broken oil flask over the flame, suggested the glass chimney which perfected the idea, confining the air immediately round the burner, and causing the flame to rise higher and burn brighter.

Argand had trouble with his invention from the first. No sooner had he made his lamp known, than Ambroise Bonaventure Langé, of Paris, put forward a claim to the chimney portion of the invention, and, having great influence, proved a very formidable obstacle in Argand's path, so formidable, indeed, that the latter, on going to Paris to substantiate his claim as sole inventor, considered it expedient to allow Langé to join him in the patent and share the profits. Letters patent were accordingly granted to Argand and Langé in 1787. Two years later, when the lamp was beginning to make its way into public favour, the tinmen of Paris, conceiving the invention to be antagonistic to their interests, published a pamphlet against it, in which they maintained that as Argand and Langé had so long disputed the credit of the invention, it could not of right belong to either of them. This was the condition of affairs when the Revolution broke out; and further contention was rendered useless by the decree abolishing all exclusive privileges. Nor did the injury to the original inventor stop here; one Quinquet, who introduced some unimportant alteration in the form of the lamp, had his name given to it; and Argand, discouraged and disappointed, once more went to London, where he suffered so much from poverty and privation, that at length, broken in health and spirit, he made his way back to his native city, and died there on the 24th of October, 1803. During the last year or two of his life he was possessed with some strange ideas, and fell a prey to melancholy, one of his visionary notions being "to obtain from the bones and dust of the sepulchre the means of prolonging life." It was left to posterity to settle his indisputable claim to be considered the only inventor of the lamp, which, after his death, continued to be called after him.

CHAPTER X.

WHIMS OF FASHION.

Fashion's Follies—The Evolution of the Trousers—Southey and his Pantaloons—Norman Extravagance—Charles VI. and his Surcoats of Tarred Sackcloth—The Costumes of the Plantagenet, Stuart, and Georgian Periods—The "Cutting-down" of Later Times—Fashions in Hair—The Era of Wigs—Head Decoration of Women—Gigantic Coiffures—Ladies' Hats—The Head-gear of Men—The Introduction of the "Chimney-pot"—Shoes and their Transitions—Gloves—Collars and Neckties—Fashion under better Control than Formerly.

FASHION has been not inaptly defined as "the tyrant of fops and females." But the tyranny of the so-called goddess extends far beyond these effeminate limits. Fashion is the tyrant of trade no less than of "fops and females," and is at once the hope and dread of men of invention. It is in fashion's behalf that some of the greatest marvels of modern invention have been achieved; it is to minister to the demands of fashion that the best part of the textile industries of the world have been established, and are sustained; and it is in the interests of fashion that art and eccentricity constantly combine in the production of novelty or change. How imperious and absolute this impersonality is, its victims only can fully realise. A whim of fashion can make a trade or ruin one, can indicate to struggling inventive genius new paths of profit and honour, or render useless the mechanical growths of a lifetime. Fresh fabrics, the result of long and patient labour, revealing exquisite beauties of texture and design, are for ever being laid at the feet of this inexorable despot; but all their worth, loveliness, and utility, are as nothing unless her fickle fancy is caught.

"Necessity, the mother of invention," first prescribed the skins of animals as articles of dress, which were submitted to no softening process but simply donned in their raw state, with the hairy side turned inwards for warmth. Then folk began to think of appearances, and the hair was worn outside, the favourite garb of an early Briton being the skin of a spotted cow. The heroes of ancient Greece clothed themselves in the skins of lions and tigers, and other terrible animals. Rebecca dressed Jacob with strips of goats' skins. The art of manufacturing wool and flax—an invention ascribed to Isis by the Egyptians, who were the first to practise the art—provided garments of softer texture, and opened up a field of variety and luxury to the "fops and females" of the early civilised nations. Then came the dyer, with his rich scarlets, purples, blues, and yellows, and the Greeks and Romans revelled in garments in which all the hues of the rainbow were imitated. Furs were also introduced for dresses of luxury. The Scythians, the Goths, and the Huns wore furs, and amongst the Norsemen the wearing of rich skins prevailed to a late period. Silk, in its various forms, was also brought into use, and dress gradually began to be regarded, first, as an adornment, and then, as an object of comfort.

It would be a long task to trace fashion through all its various stages, from the rugged skin raiment of the barbaric ages to the classic garbs of Greece, from the Roman toga to the frock-coat, from the Phrygian cap to the "chimney-pot" of the present time. A rapid glance at some of the more distinctive changes and oddities must suffice.

The evolution of the trousers is a somewhat curious study. The toga and the tunic were of a feminine character, but neither of these garments did anything for the lower limbs, which were not always so shapely as they might be, and left the victim of crookedness or leanness open to the scorn and ridicule of his fellows. Bandages then came to be worn round the legs of such as suffered from weakness, and, although at first looked upon with much disfavour, this custom gradually extended until bandages came to be reckoned amongst the ordinary articles of dress. The next step towards trousers was the full loose *braccæ* of the Gauls, which were tied round the ankle with a cord and ended in a kind of fringe above the foot. This was a portion of costume which the British carried with them to Rome; but the Romans despised the *braccæ* of the barbarians, and not only prohibited the use of the garment, but under the reign of Honorius and Arcadius the makers of *braccæ* were expelled the capital. It was not long, however, before fashion took an idea from the rejected garment of the British and invented the "brech," or breeches proper, and hose, which for many centuries served to cover the loins and legs of fashionable male kind. When the Romans adopted the breeches, though, they claimed to be following the fashion of the Persians, whose *anaxurides* were garments of a similar kind.

The next transition, very much later on, was from breeches to pantaloons. St. Pantaleon is the patron saint of the last-mentioned garment, and belongs to Oporto; but it was in Venice that the trunk-hose first gave way to pantaloons, and thence came, by way of France, to England. For a time they were much in favour, but gave way to breeches again during the reign of the dandies and beaus of the latter part of the last and the early part of the present century. Amongst the inventors of novelties in breeches Jean de Bart ought to be mentioned, who had a full dress pair which were made of cloth of gold, lined with cloth of silver. Pantaloons on coming in again soon began to widen, and expanded by degrees into loose trousers, which attained their culminating point of roominess some quarter of a century ago, when what was called the "peg-top" style was in vogue. Southey once accorded a pair of pantaloons a sort of literary welcome, writing of them in his Commonplace Book in this wise:—"I, who like to go with the stream, and am therefore content to have fashions thrust upon me, have just received a new pair from London. . . . I cannot approve the colour. It hath too much of the purple; not that imperial dye by which ranks were discriminated at Constantinople, nor the more sober tint which Episcopacy affecteth. Nor is it the bloom of the plum; still less can it be said to resemble the purple light of love. No! it is rather a hue brushed from the raven's wing, a black purple; not Night and Aurora meeting, which would make the darkness blush; but Erebus and Ultramarine. Doubtless it hath been selected for me because of its alamodality—a good and pregnant word—on the fitness of which some German, whose name appears to be erroneously as well as uncouthly written Geamoenus, is said to have composed a dissertation."

Simplicity of dress prevailed in England up to the time of the Conquest, but the Normans gave way to lavish extravagance, and were most assiduous fashion-hunters. The blouse was copied by them with slight modifications from the smock-frock of the Saxon labourer. In winter, the Norman nobles lined it with fur and wore it as a surcoat over their armour. And what freaks fashion played with that same armour! The mediæval knights were as vain over their metallic clothes of defence as their ladye-loves were over their gowns and head-gear. At one time the armour was trellised (cross-barred), at another time it was mascled (lozenge-shaped), then it was tegulated (in tile form), then scaled; now it was of chain mail, now of plate; fashion prescribing sometimes a nose-piece for the helmet, sometimes making the head-piece a barrel, a kettle, or an inverted saucepan, or changing to a chain nightcap, or a projecting visor, with eye-slits and breathing holes.

When in the enjoyment of idleness, the nobles indulged in the most fantastic attire, gadding abroad in mantles and loose sleeves of cloth of gold, velvet, ermine, and miniver of enormous amplitude. Even the common serving men of that period went about with scarlet robes twenty yards wide and sleeves trailing to the ground. The French were still more outrageous in their follies of fashion. In 1393, Charles the Sixth invented a fashion which nearly cost him his life. He and five young nobles dressed themselves as savages, first putting on surcoats of tarred sackcloth and then rolling themselves in tow, so as to seem all covered with long hair. Thus attired, they advanced, dancing and clanking chains, into the royal ball-room, when his Majesty detached himself from the rest and entered into conversation with one of the royal duchesses. "Sire," said Messire Ivain de Galles, "we had better keep the torches out of the way." This advice was acted on for the moment, but presently in burst the Duke of Orleans with his torch-bearers. "What! savage men?" he cried. "I'll soon singe their beards for them," and he immediately thrust a blazing torch into the face of one of the chained maskers. The next instant all the five were in flames. Four of them were burnt to death, one saved himself by jumping into a rinsing trough, and the king was almost frightened out of his senses.

The French, indeed, were always the first in anything that was fanciful or fantastic. It has been said that the English invented shirts, and that the French put ruffles to them. To this someone has replied that he would not be surprised if the ruffles came first, before either French or English had any shirts to their backs, luxury having always been quicker in development than comfort. There was not very much change in the general externals of male attire, however, from the days of the Plantagenets down to the time of the Stuarts, except as regards hats and shoes. The costume of the cavaliers was perhaps the most picturesque, as well as the most costly, that has been known; in strange contrast to the sombre quaintness and undoubted ugliness of the dress of the Puritans. There was the broad Spanish hat, with its rich jewelled band, its clasp of precious stones, or its string of pearls; the cloak, capable of a thousand variations of brightness and shade, from a mass of broad, rippling daylight to a spagnoletto gloom; the doublet fitting the form without ridiculous compression; the rich lace collar; the full Spanish hose and the small shoe, with a rosette of ribbon; the rich ruffs and falling bands of daintiest lace, and the long, flowing periwig: all of which made up a costume which formed a delightful setting for the charms of fashionable manhood. Since that period of laxity and romance, fashion has toned down the picturesqueness of man's attire until the lowest depths of commonplace have been touched. Every former prominence of dress has been cut down; mantles of gayest hues have given way to coats of funereal black, cocked hats to "chimney-pots" and wide-awakes, flowing wigs to closely cropped hair, and doublets and hose to baggy trousers; and fashion all the time has been cutting and trimming and patching in its own wilful, aimless, helpless way, with an army of inventors and artificers in close pursuit, always displaying the greatest amount of eccentricity in connection with its head and foot gear.

The ancient Briton, with his tattooed skin and spotted cow-hide suit, allowed Nature to have its own way with his hair, without even the interference of a comb, and it heaped itself in wavy masses about his neck and shoulders. Long hair prevailed, more or less, down to the reign of Henry VI., when it was cut close and straight round. The next Henry went back to the long hair; Henry VIII. shortened it again; the Cavaliers favoured flowing locks; the Puritans declined to let their hair flow in any way; the Merry Monarch made periwigs the fashion, and wigs of one sort and another continued to hold their sway down to the days of our grandfathers. What marvellous shapes these head-ornaments took from time to time! "Huge Cape-sheep tails," says an authority, "tied with monstrous blue bows; long flows of wool, fluffy and full, flapping down to the waist like exaggerated spaniel's ears, things large enough for a camel's load, and bearing a bushel of powder; campaigns, bobs, pig-tails, bags, toupees, like sugar-loaves, both male and female, the male with a row of cannon curls at the nape of the neck, the female bordered to the apex of the pyramid with rolls like Brobdingnagian sausages; pigeons' wings, comets, and cauliflowers, royal birds, staircases, ladders, and brushes, wild boars' backs, temples, rhinoceri, corded wolf's paws, Count Saxe's mode, the dragons, the rose, the crutch, the negligent, the chancellor, the cut bob, the long bob, and the Jansenist bob, the half natural, the chain buckle, and the corded buckle, the drop wig, the snail's back, spinach seed, and artichoke, were a few of the names given to these creations of tow, powder, and nastiness." Louis XV. invented what he called the solitaire, by tying a piece of black ribbon loosely round his neck and fastening it in a bow to his pigtail behind. When at last a daring individual, to whom the expense of a wig had probably grown wearisome, left the false hair off and appeared only in that which nature had given him, there was a great outcry of shame and derision. So, in order that the change should not be too sudden, for a time the hair was powdered and pomatumed in imitation of the wig. One alarmed peruke-maker proposed a poll-tax upon all who wore their own hair, and even some of the writers of the period placed their wit at the service of the wig party. The coachman in the *Rivals* observes that the exciseman has taken to his carrots. But the doom had been decreed, and although the wig died hard, die it did, and now only remains as the badge of justice or servitude.

The head decoration of women has been more fearful and wonderful still. In early times they plaited their hair into long pendent tails and hid it away in silken cases; in Chaucer's time cauls of golden network, adorned with jewels, were worn, hair-dye being much resorted to; in Edward IV.'s reign the hair was arranged in the form of horns of such prodigious proportions that ladies had to kneel on the floor of their carriages to make room for them; Queen Elizabeth powdered her hair with gold-dust and rolled it over cushions, making it hideous with ornaments; inverted pyramids of curls were the fashion in the time of James I.; the beauties of the court of Charles II. revelled in love-locks, crève-cœurs, and ringlets, which they wore in puffed-out arrangements down their cheeks; and the coiffures of the Queen Anne period comprised some of the most hideous erections that ever perruquier invented, ranging from representations of frigates in full sail to baskets of flowers, from a litter of pigs to a waggon and horses. The hairdresser who invented the "hedgehog" would not pay a visit under a charge of £20. "It is considered a particular beauty," wrote Lady Mary Wortley Montagu from Vienna, "to have a head too large to go into a moderate tub." It took several hours to dress a lady's hair in those days, and when once dressed it had to last as many weeks as it had taken hours to build up. As far as concerned France, Louis XIV. *dis*invented (if the word may be permitted) gigantic coiffures at a breath. "Cette coiffure me paraissait désagréable," said the Grand Monarque, and on the next day all the ladies of the court presented themselves with their hair low down upon their heads. There have been many eccentric fashions of hair arrangement since then—now the fair tresses have been gathered up in a net behind the head, now piled up on the top in the form of a chignon, now hanging loose down the back, and now cut short like a man's, but Nature has no longer been outraged to the same extent as when coiffures three or four storeys in height were worn and had to be slept in.

Ladies' hats have undergone equal change. There have been hoods, horse-shoes of velvet and cloth of gold, extinguishers, turbans, coifs, Marie Stuart hats, saucy feathered hats, coal-scuttles, helmets, pokes, bonnets of immense size, and bonnets of hardly any size at all. A wag of a versifier, writing about the minimum period, has given the following "Recipe for a Bonnet":—

"Two scraps of foundation, some fragments of lace,
A shower of French rosebuds to droop o'er the face;
Fine ribbons and feathers, with crape and illusion,
Then mix and *de*-range them in graceful confusion.
Inveigle some fairy, out roaming for pleasure,
And beg the slight favour of taking her measure,
The length and breadth of her dear little pate,
And hasten a miniature frame to create;
Then pour, as above, the bright mixture upon it,
And lo! you possess 'such a love of a bonnet!'"

The head-gear of men has not been submitted to quite so many changes. The men of old wore hoods with long tails called "liripipes" for their heads; then followed caps with high feathers; and in the fourteenth century felt hats began to be worn. At first they were made from lambs' skins, and afterwards from the skins of beavers. Before then the Norman knights had adopted a hat something of the shape of the wide-awake of recent times. It was this hat that Innocent IV. took for the form of the Cardinal's hat, simply accepting it as it was and dyeing it scarlet. It was at the Council of Lyons, in 1245, that the red wide-awake of the Cardinals was first worn. Then there were peaked hats, scarlet caps, broad brims and peaked crowns, and looped brims and feathers. It was the gradual expansion of the brim that led to the device of looping up, and following on this came the fashion of "cocked hats." There was the "Monmouth cock" and the "Brunswick cock;" and, later on, the hat was looped up equally on three sides, and thus resulted the cocked hat that was worn through the greater part of the eighteenth century. The first variety of the chimney-pot was introduced at the time of the French Revolution, and this has been gradually altered to its present cylindrical shape, fashion having declined to meddle with it for nearly a hundred years, except now and then to suggest an extra curl to the brim, or an additional half-inch to the height of the crown. It was a Parisian hatter named Leprevost who invented the art of making hats of silk stuff, and silk hats have ever since continued to be the favourites of fashion. Rabbit-skins are now chiefly used in the making of felt hats. England alone collects about 30,000,000 rabbit-skins annually, and France 80,000,000. The English trade in rabbit-skins amounts to at least £200,000 a year.

Fashion has issued many edicts concerning shoes. Leather, papyrus, rush, and wool were used for shoes thousands of years ago by the Egyptians and the Hebrews. Shoes are frequently mentioned in the Bible, from the Book of Exodus onwards. Among the ancient Greeks the women of distinction wore sandals; the Lacedæmonians wore red shoes. Shoes reached to the middle of the leg in those days, and were often made of gold and silk. The Romans had the calceus, which covered the entire foot, and the sandal, which protected only the sole. In England shoes of raw cow-hide were worn in early times. A gentleman of fashion who lived in the reign of William Rufus, called Robert the Horned, invented a pair of shoes with long sharp points, stuffed with tow, and twisted in a spiral form. These so pleased the young bloods of the day that they were at once proclaimed the mode, and became highly popular. But, unfortunately, points having been once introduced they did not know where to stop with them. Year by year they were increased in length, until in the time of Richard II. they had to be tied to the knees. The greater the personage, the longer the shoe-toe. This continued until the reign of Edward IV., when that monarch found it necessary to publish a law that no one under the rank of a lord should wear points more than ten inches in length. After that shoes began to assume something of their present shape, though great personages still indulged in costly and fanciful coverings for their feet. Sir Walter Raleigh had a pair made of buff leather, and adorned with gems to the value of £6,600. The existing style of shoe was introduced in 1633, and buckles in 1670. Boots, laced at the sides, and clogs came into vogue in the reign of Henry VI. The boot of the Restoration, with its wide soft top to show the lace lining, the stiff jack-boot of the James II. period, and the Hessians and Wellingtons of a later date, are all distinct features of past fashions.

Gloves have kept pace with shoes pretty well. Homer mentions them, and the Greeks and Persians wore them. Glove-making was an extensive trade in France in the eighth century; but it was not till the end of the tenth or the beginning of the eleventh century that gloves found their way to England, and not until the fourteenth century that they were generally worn. In 1622, a pair of Woodstock gloves worth forty-four shillings were presented by the University of Cambridge to its Chancellor. Indeed, glove-making, from the fifteenth century, had become a popular industry in England, and foreign gloves were not allowed to be imported until 1825. Gloves of rich embroidery, and highly perfumed, were much worn by great personages in the sixteenth century; gauntlets came into fashion in the reign of Edward I., but ceased to be used when armour was no longer part of a warrior's equipment. It was at one time a popular saying that in order to produce a good glove Spain must prepare the leather, France cut it out, and England sew it. There have not been the possibilities of change of fashion in gloves that there have been in other articles of attire; still, almost every year sees the introduction of some novelty in these articles, which are made in every variety of material and colour, the inventor finding plenty of scope for his ability in the devising of new methods of fastening for them, if nothing else.

It would be easy to write a chapter on collars and neckties, on which fashion and invention have spent so much time—to speak of the introduction of the "falling bands" which Henry III. of France imported from Italy, of the starched ruffs of the same reign, of the "dog-collar," the "stand-up collar," the "all-round collar," the "Byron," the "Shakespeare," the "masher," and so forth of this later time, did space allow. The cravat got its name from the Croats, a regiment of whom, all throttled in cravats, arrived in Paris in 1600, and set the new fashion in neck-swathings. Cravats kept in vogue until the eve of the Revolution, when, as if in anticipation of the reign of the guillotine, throats were allowed to go bare. When the Terror was over, cravats once more came into fashion, and were retained in favour for some quarter of a century longer. Napoleon wore a white cravat at the battle of Waterloo. In 1822, George IV. invented or introduced the stock, which was made of Genoa velvet or silk, and at once became the rage, completely killing the cravat; and the stock has, in its turn, been superseded by the more comfortable tie, which may be regarded as a free and easy adaptation of the cravat. When Beau Brummel assumed the guardianship of fashion in this country, it was not considered fitting that a gentleman should travel with fewer than eighty cravats, and an iron for smoothing them.

Fashion is, perhaps, not quite so eccentric now as in former days; still, it has some strange vagaries, and all along leads the social world a pretty dance. It may be that our ladies will not again return to the fashions of centuries ago, when the sex surrounded themselves by a terrible fortification of whalebone, wood, and steel, and kept themselves rigid and impregnable by iron bodices, stiff farthingales, and vast circumferences of hoops; yet we have not long since left behind us the crinoline, of which the later crinolette was the offspring. And it may be also that the mannish ladies of the past—the "petticoat breeches" wearers of the second Charles's time, and the Bloomer votaries of five-and-thirty years ago, for example—will not be outdone in audacity by the women of the future; still, the "divided skirt" is, to-day, a much advocated invention in certain circles, and might lead us into no one knows what eccentricities of compromise between male and female styles if once fashion did but smile upon it. Our safety lies in the necessity of modern times—convenience and comfort. The dress that stands in the way of these, stands in the way of itself. Fashion may indulge in whatever caprice it pleases, so long as it refrains from imposing fetters upon our freedom of movement.

CHAPTER XI.

ROYAL AND NOBLE INVENTORS.

The Inventions of Attalus, Belisarius, King Alfred, and Elizabeth of Hungary—Rudolphus II. and the Odometer—Archduke Cosmo—Louis XI.'s Organ—The Inventions of Prince Rupert—The Marquis of Worcester—Alleged Interview with Solomon de Caus—The Germ of the Steam-engine—"The Century of Inventions"—How the Marquis dispersed the Roundheads—The Marquis's Minor Inventions—Sir William Petty's Copying Machine—Sir Samuel Morland's Speaking Trumpet—Lord Thurlow suggests an Invention—Lord Petersham as an Inventor of Blacking, Snuff Mixture, and other Matters—George IV. Invents the "Stock"—The Earl of Dundonald's Coal-tar Invention—Earl Stanhope and his Printing Press—What it Cost him.

IN these days we do not look for inventive effort on the part of persons of exalted rank. It is rather at the other end of the social scale that we expect the genius of invention to show itself. But, in the olden time, when class distinctions were more marked, and the poorer orders were in a condition little better than slavery, it was different; then, such progress as was made was mainly the outcome of the higher culture of exceptionally gifted members of the upper ranks; the toilers and workers had plenty to do to preserve their bare privileges, without troubling their heads with matters of mechanical invention. Besides, there was no such incentive to invention then as exists to-day; the field of operation was so limited, the reward so small; thus invention was rather an amusement than a thing of serious, ambitious aim. No wonder that kings and nobles should be amongst the inventors of ancient times.

Attalus is said to have invented the art of interweaving gold threads in cloth, though whether this was done with the needle or by the actual process of weaving, remains a matter of conjecture. Belisarius, when besieged at Rome by the Goths, in 536, invented floating corn-mills, which he placed on the Tiber, the enemy having stopped the fourteen large aqueducts which supplied the baths and drove the ordinary mills. King Alfred's invention of a mode of measuring time by candles, is too well known to require more than a passing reference. The decoction known as Hungary water was the invention of Elizabeth of Hungary, wife of King Charles Robert, and daughter of Ladislaus II., King of Poland. By this water, which is spirit of wine distilled upon rosemary, the queen is said to have cured herself of the gout "and an universal lameness," when in the seventieth year of her age, so that she not only lived to pass eighty, but became so lively and beautiful that her hand was sought by the then King of Poland, he being a widower and she a widow. She, however, "refused him for the love of my Lord Jesus Christ, from one of whose angels I believe I received the remedy."

The emperor, Rudolphus II., who reigned from 1576 to 1612, was a monarch of a decidedly inventive turn, concerning himself much with the mechanical arts, and producing many improvements in machines of various kinds. He is credited with having constructed an odometer, or road measurer, which not only marked out the distances travelled, but noted them down on paper. Cosmo, grand duke of Tuscany, invented a preparation, in 1555, by which steel and other hard substances could be softened. According to Vasari, he had a large block of porphyry, from which he desired a basin to be made for a well, but was told by the most experienced artists that it was impossible. Cosmo therefore prepared from certain herbs, which are not named, a water wherein the red-hot tools were quenched, and by these means so hardened them that they were capable of cutting porphyry. Francesco del Tadda, it is said, made the required basin, and many other articles, with tools tempered by this water.

At the first blush it would hardly be expected that a monarch so cold and crafty as Louis XI., of France, should figure in the list of inventors; it is nevertheless a fact that his royal brain did once give forth an idea for an invention which has been called an organ, but which might more appropriately, perhaps, be classed with instruments of torture. It was in keeping with the man, however, and, partly, with the time, and therefore merits description. It is related that, during one of the intervals of his playing the part of "universal spider," the king caused the Abbé de Baigne, the master of the royal music, to make a "pig-organ," his majesty personally directing its construction. Pigs of different ages and sizes were procured, and placed in rows in a tent, in order according to the pitch and quality of their grunts and squeaks. In front of the tent a keyboard was erected, each key acting upon a sharp-pointed instrument capable of exciting the anguish and terror of the unhappy animal with which it came in contact. When the performer began to play, the voices of the swine rose on the air in demoniacal squeals, but still with some approach to musical scale, and with an effect that was no doubt highly impressive. Kings had to be amused in those days, at whatever cost.

Coming down from kings to princes, we find a member of the royal family of England figuring as an inventor on a large scale, in the troubled times which extended from the stiff artificiality of the days of the first Charles, to that period of gay relaxation which distinguished the reign of the second monarch of that name. The prince in question was none other than Prince Rupert, to whose accidental discovery of the mezzotinto process we allude in another portion of this volume; he had inventive gifts of a high order, and might have made an impression far deeper than he did upon the useful arts had he been born in a later time, and had he not had the misfortune to be a prince. It will be remembered that this illustrious personage, of whose feats of arms we hear so much in connection with the Civil war, was the third son of the King of Bohemia, by the princess Elizabeth, eldest daughter of James I. After the Restoration he received the appointment of Governor of Windsor Castle, and resided there for the most part up to the time of his death in 1682.

While living thus retired, he devoted himself to the work of invention, producing, amongst other things, a variety of improvements in firearms. He constructed a gun "for discharging several bullets with the utmost speed, facility, and safety;" and devised a new method of boring guns, as well as of annealing the metal for guns. In truth, little came wrong to him, from fulminating glasses to fish-hooks. The prince had a glass house adjoining Chelsea, where some of his more particular experiments were prosecuted. By some writers he has been credited with the invention of the glass drops which are associated with his name, while others maintain that he simply introduced them to this country. It is certain, however, that their discovery belongs to the prince's time, and that they bore an important part in the development of the glass manufactures of Europe. They would hardly have been by common consent styled Prince Rupert's drops by Continental nations, unless he had been something more than the mere introducer of them from one country to another. There can be no doubt, however, that his Highness was the inventor of the composition which came to be known as Prince's metal. He communicated to the Royal Society certain improvements in gunpowder, which he accomplished by refining the several ingredients, and making it more carefully, augmenting its force "in the proportion of ten to one, as compared to ordinary powder." To the same learned society he presented particulars of "a certain method of blowing up rocks in mines and other subterranean places," an invention "for making hail shot of all sizes," an "engine he had contrived for raising water," and an instrument "for casting any platform into perspective, and for which they deputed a select committee to return him their thanks." He is likewise said to have devised a particular kind of screw, "by means of which observations taken by a quadrant at sea were secured from receiving any alteration by the unsteadiness of the observer's hand, or through the motion of a ship." Furthermore, we are told that he had also, "among other secrets," that of melting or running blacklead, like a metal, into a mould, and reducing it again to its original form; and, to show that he could bring his mind on occasion to the level of the most peaceful and pastoral of pastimes, he condescended to invent a "mode of tempering the Kirby fish-hooks."

It is pleasant to think of the hero of so many sanguinary battles, and the gallant and unswerving supporter of the cause of his royal and unfortunate kinsman, employing the evening of his life in furthering the mechanical arts, though his inventions for the greater part were intended for warlike purposes. On sea as well as land, in the councils of war no less than in the seclusion of the laboratory, this ingenious prince appears to have deserved the praise that his contemporaries so warmly bestowed upon him; but it is as the leader in arms, rather than the man of science, that history knows him best. Dryden, in his *Annus Mirabilis*, has described him as,

> "Secure of fame whene'er he please to fight;
> His cold experience tempers all his heat,
> And inbred worth doth boasting valour slight,
> Heroic virtue did his actions guide,
> And he the substance, not the appearance, chose."

Amongst the noble inventors of the seventeenth century, there is no name stands so high in England as that of the Marquis of Worcester, who, in his oft-quoted "Century of Inventions," appears to have anticipated most of the great inventions that have since been perfected. The Marquis fell upon an evil day—upon a time of strife and bloodshed, when a man's thoughts had to be given to arms and contention. Pledged to Charles I., he supported that pledge honourably and bravely, even to the sacrifice of his fortune and position, and when he could do no more, he retired to France with young Prince Charles, and continued to live there in poverty until the Restoration paved the way for his return, and provided him with better means and an opportunity of putting before the world a list of his many curious, and some highly important, inventions. He published his "Century" in 1663. This professed to give "the name and scantlings of such inventions as at present I can call to mind to have tried and perfected;" and included, as its chief feature, what has been generally accepted as being the germ of the steam-engine.

It has been stated that the Marquis was originally indebted for his notion of the steam-engine to Solomon de Caus, whom he is said to have visited during his confinement in the Bicêtre, the fascinating Marion Delorme acting as his escort. In a letter, the genuineness of which is open to doubt, this lady is supposed to relate the manner of the introduction of the Marquis to De Caus. She expresses her delight in being able to do "the honours of Paris to your English lord, the Marquis of Worcester," describing him with all a Frenchwoman's piquancy as "choosing always the most sad and serious words, speaking but little, listening with great attention, and fixing his large blue eyes upon every one of whom he asks a question, as if he could see into the depths of their souls; he is never satisfied with the explanations he receives, and does not look upon things exactly as they are shown to him." Then she goes on to give an account of the Marquis's interview with De Caus. "When we visited the Bicêtre," she says, "he pretended to see marks of great genius in a crazy man, whom, if he were not raving, I am sure your Englishman would have taken to London, if possible, and listened to his nonsense from morning till night. As we crossed the yard filled with these creatures, I was half dead with fright, and leaned against my companion. Suddenly an ugly face appeared behind the bars, and a hoarse voice exclaimed, 'I am not crazy. I have made a discovery which will enrich the country that so violently opposes it.' 'What is his discovery?' I asked the man who showed us over the place. 'Ah!' exclaimed he, shrugging his shoulders, 'something very simple, which you would never guess—it is the use of steam.' I burst out laughing. 'His name,' continued the keeper, 'is Solomon de Caus. He came from Normandy, four years ago, to present a memoir to the king on the subject of the marvellous effects to be obtained by his invention. According to him, machinery could be moved by it, carriages propelled, and numerous other wonders effected. . . . . The Cardinal sent away the fool without listening to him. But De Caus, undiscouraged, followed him from place to place, until Richelieu, weary of his importunities, had him shut up in this place, where he has now been three years and a half. He tells every stranger he sees, as he tells you, that he is not crazy, but has made a grand discovery. He has even written a book upon the subject.' And so saying, he handed us a book. My lord Worcester took it, and, after reading some pages, said, 'This man seems by no means insane; and were he in my country, instead of being shut up, he would have made his fortune. Bring him hither. I wish to question him.' He returned from this conversation with a sorrowful countenance. 'Alas! he is indeed crazy now,' said he; 'misfortune and captivity have for ever destroyed his reason; this cruel usage has made him mad. But, when you put him in this prison, you incarcerated the greatest genius of his day.' Hereupon we took our leave, and since then he has done nothing but talk of Solomon de Caus."

Whether this letter is a forgery or not, it is not improbable that such an interview as described did take place, and that it made a deep impression upon the receptive mind of the Marquis, and it may well be that the book published by the unfortunate De Caus at Frankfort, in 1615—"*Raisons des Forces Motives*"—would subsequently be obtained and read more carefully than had been possible in the hurried glance given to it in the prison. One way or another it is extremely likely that the master of Raglan Castle did see De Caus's book, and that it set him thinking and experimenting, and it is pretty certain that he did later on construct a machine in which the principle of the steam-engine, however crudely and imperfectly, was demonstrated. The Marquis's own description of his invention has such an important bearing upon this question that we cannot do less than quote it. It is catalogued as "An admirable and most forcible way to drive up water by fire, not by drawing or sucking it upwards, for that must be as the philosopher calleth it, *Intra sphæram activitatis*, which is but at such a distance. But this way hath no bounder if the vessels be strong enough; for I have taken a piece of a whole cannon, whereof the end was burst, and filled it three-quarters full of water, stopping and screwing up the broken end; as also the touch-hole, and making a constant fire under it; within twenty-four hours it burst and made a great crack. So that having a way to make my vessels, so that they are strengthened by the force within them, and the one to fill after the other, I have seen the water run like a constant fountain stream forty foot high: one vessel of water rarefied by fire driveth up forty of cold water. And a man that tends the work is but to turn two cocks, that one vessel of water being consumed another begins to force and refill with cold water, and so successively, the fire being tended and kept constant, which the selfsame person may likewise abundantly perform in the interim between the necessity of turning the said cocks."

This invention was undoubtedly the Marquis's master-work, and was so regarded by himself, for, after the manner of his time, he offers up (and publishes) an "ejaculatory and extemporary thanksgiving prayer when first with his corporeal eyes he did see finished a perfect trial of his water-commanding engine," for which, "next to his creation and redemption," he rendered the "most humble thanks ever from the bottom of his heart and bowels," for "vouchsafing him (the meanest in understanding) an insight in so great a secret of nature beneficial to all mankind as that his water-commanding engine."

It is much to be regretted that there exists no exact record of the practical putting into operation of this invention, and that no model of it was preserved; but the times were hardly ripe for any public interest being taken in such an engine, and, moreover, the Marquis was poor and had not the means to develop his ideas thoroughly. Three other items of his "Century of Inventions" relate to the same idea, but in the remaining ninety-six we read of some amusing and often whimsical articles, as well as of some which seem to be the forerunners of great mechanical practicabilities. Some of his machines he brought into operation against a party of his Roundhead enemies on their paying an unwelcome visit to his castle, during the time of the Civil War. These were the hydraulic engines by which water was raised to the top of a tower, whence it could be drawn off at pleasure for the service of the house. Instead of meeting the foe with a shower of shot, he directed his servants to turn the full force of the waterworks upon the "psalm-singing knaves," which they were only too delighted to have the opportunity of doing. "There was such a roaring," wrote his lordship, "that the poor silly men stood so amazed as if they had been half dead: and yet they saw nothing. At last, as the plot was laid, up comes a man staring and running, crying out before he came at them, 'Look to yourselves, my masters, for the lions are got loose.' Whereupon the searchers gave us such a loose, that they tumbled so over one another down the stairs, that it was thought one half of them had broken their necks; never looking behind them till they were sure they had got out of sight of the castle."

The minor inventions of the Marquis comprise several methods of secret writing; a system of telegraphy, by which a person "at a window, far as eye can discover black from white," may "hold discourse with his correspondent, without noise made or notice taken;" another plan of telegraphing "by night as well as by day, though as dark as pitch is black;" an engine portable in one's pocket, which may be carried and fastened on the inside of the greatest ship, *tanquam aliud agens*, and at any appointed minute, though a week after, either of day or night, it shall irrevocably sink that ship." This last is, surely, one of the earliest notions for the wholesale destruction of ships, but one would imagine the portable engine would neither be a very acceptable article for the pocket or particularly safe to the person who undertook the duty of fastening it to the ship. Then he propounds, as a set-off, a number of notions for protecting vessels, one of which was to "make a ship not possible to be sunk, though shot at a hundred times between wind and water by cannon, and should she lose a whole plank, yet, in half an hour's time, should be made as fit to sail as before."

What a pity the Marquis had not lived in these times! Amongst the later race of makers of marine and submarine machines of destruction his genius would have found a welcome. He hops about in his "Century," however, from life-taking and life-saving agencies to more pleasing odds and ends of inventions; such as one for making "upon the Thames a floating garden of pleasure," and one for lighting "a fire and a candle, at what hour of the night one awaketh, without rising or putting one's hand out of bed." His "pistol to discharge a dozen times with once loading" seems something akin to Prince Rupert's gun for discharging several bullets, but still nearer in kinship to the modern revolver. Then he has a "chair made *à la mode*, and yet a stranger, being persuaded to sit down in it, shall have immediately his arms and thighs locked up, beyond his own power to loosen them;" and "a watch to go constantly, and yet needs no other winding from the first setting of the cord or chain."

The majority of these miscellaneous inventions are so far away from our common experience, that, even with the additional enlightenment which we are supposed to enjoy in this penultimate decade of the nineteenth century, and with all our later expansion of mechanical knowledge, we should only be inclined to accept them *cum grano salis*, did we not know what seemingly incredible things *have* been done by inventors. It needs all our hardihood, however, to "swallow" the Marquis's invention in small cannon which he states was "tried and approved before the late King (of ever blessed memory) and a hundred lords and commons." According to the description, it was "a cannon of eight inches and half a quarter," and was capable of shooting "bullets of sixty-four pounds weight, and twenty-four pounds of powder, twenty times in six minutes; so clear from danger, that after all were discharged, a pound of butter did not melt, being laid upon the common hitch, nor the green oil discoloured that was first anointed and used between the barrel thereof, and the engine having never in it, nor within six foot, but one charge at a time."

It is probable that if the Marquis of Worcester had given us something less than a full "century" of inventions—limited himself, in fact, to the half dozen leading ones in his list—he would have held a higher place than he does in the history of invention. As it is, there is so much to smile at in his lesser inventions, that the smile never wholly leaves us even when the Marquis's higher achievements are under examination. All the same, he must ever be regarded as one of the pioneers of the steam-engine, and in that prominent position will descend on the roll of fame to the distant future. If the literature of the seventeenth century had busied itself to any considerable extent with mechanical matters, there would doubtless have come down to us much acceptable corroboration of the Marquis's inventions; as it is we have to take his word—the word of a nobleman and a gentleman, be it understood—for his own work, for the most part, and be thankful that we can get even that. Dryden (or, perhaps, more correctly, Nahum Tate for him) has an allusion in *Absalom and Achitophel* to the Marquis's son and successor, who was afterwards created Duke of Beaufort, but not a word about the inventor-Marquis. The poet describes the son as one—

> "On whom so largely Nature heaped her store,
> There scarce remained for arts to give him more;
> To aid the Crown and State his greatest zeal,
> His second care, that service to conceal."

But it was not because of his achievements in the arts in which his predecessor had taken so deep a pride that he won the favour of his king, but by virtue of those smaller accomplishments which are not beyond the comprehension of a monarch who lives only for pleasure.

Sir William Petty, in the time of the Commonwealth, amused himself with a copying invention, the description of which may serve to show the condition of chirographic appliances in those days. The instrument was specified as being "of small bulk and price, easily made, and very durable, whereby any man, even at the first sight and handling, may write two resembling copies of the same thing at once, as serviceably and as fast (allowing two lines upon each page for setting the instruments) as by the ordinary way; of what nature, or in what character, or what matter soever, as paper, parchment, a book, etc., the said writing ought to be made upon." This invention was styled a pentagraph, and was patented for seventeen years.

Sir Samuel Morland, who won a place of esteem under Charles II., was another titled person who seems to have been of an ingenious turn. The invention of greatest utility associated with his name is the speaking-trumpet, which he introduced to the King and Prince Rupert, performing several experiments before them with it, to their great astonishment. His first instrument, shaped like a wide-mouthed trumpet, was made of glass; but he subsequently adopted copper as a more suitable medium. This invention was one of real value; and though others have claimed to have been before him in the field with an instrument of this description, it seems to be almost beyond doubt that Sir Samuel Morland's speaking-trumpet was the first really effective attempt to produce anything of the kind. His other inventions are of less note, and are connected with the secrets of correspondence, in the preservation and detection of which so much trouble was taken in those days. Here was a pretty invention: a method of opening "any letter, though written and sealed up with all the care and nicety that is practicable; and, having copied out the contents, to seal the same up again, with as many as shall be desired, provided he has the same paper, wax, and mark, that the party that wrote and sealed it shall be so far from discovering his letter to be opened or disfigured, that he shall not know his own letter from the other counterfeits." This was clearly an advance upon the pentagraph. Sir Samuel Morland also discovered a way of washing "a written paper as white as before it was written," and a method of counterfeiting all handwriting "so dexterously, that, upon occasion of state, the King may send the copies and keep the originals of any letters, despatches, or other papers, till any designs be ready for conviction." That must have been a very acceptable invention of his, too, which enabled the user of it to "copy any number of whole sheets of paper, close written on both sides, in as many minutes' time, with this advantage, that it will be impossible for the copies to be erroneous." This knight and baronet was doubtless a useful official.

Since the Marquis of Worcester's days, not many noblemen have troubled themselves with inventions. Lord Thurlow certainly did suggest that a wooden machine might be invented to draw bills and answers in Chancery; but that was one of those legal jests which seem to be more appreciated in the profession than out of it. Then there was Lord Petersham. He was an inventor in real earnest. According to Captain Gronow, his lordship invented a particular sort of blacking which he firmly believed would eventually supersede all other; he also invented a snuff mixture, and gave his name to a particular kind of coat which became very fashionable. Lord Petersham's favourite colour was brown—he did *not* invent that—and his carriages were brown, his horses brown, and the liveries of his servants brown, all because (our prince of gossips has written) he had once been desperately in love with a very beautiful widow whose name was Brown.

The Earl of Dundonald was another noble inventor of the eighteenth century. During the American war the supply of vegetable tar to this country was stopped, and various people began experimenting with the view of producing some sufficient substitute. A firm of lampblack manufacturers at Bristol attempted to utilise oil from pit coal for this purpose; and they were evidently on the right track, for the Earl of Dundonald took the matter up, and obtained a patent in 1785 for an invention by which, by various degrees of boiling, tar of even a better quality than the vegetable tar could be produced from coal for the bottoms of ships.

The last of English noblemen to figure in any eminent degree as an inventor was the late Earl Stanhope, of whom the Earl of Chatham said:—"Charles Stanhope, as a carpenter, a blacksmith, or millwright, could in any country, or in any times, preserve his independence, and bring up his family in honest and industrious courses, without soliciting the bounty of friends or the charity of strangers." The invention by which his name will be chiefly remembered is the printing press which bears his name. This press was a great improvement upon any previous machine, and at the time of the introduction of the steam-printing press of Koenig was the most generally used. Lord Stanhope also invented improvements in stereotyping, made a calculating machine, and suggested valuable new contrivances in regard to the construction of locks and canals. It is to be regretted that his mechanical zeal was the cause of a separation between himself and his wife, but such was the case; he insisted on his boys learning some trade so as to prepare them for the worst in the case of any social upheaval such as the French Revolution seemed to threaten. Lady Stanhope objected; hence the difference that arose between them.

CHAPTER XII.

INVENTIONS OF PUNISHMENT.

The Swift and Simple Punishments of Primitive Times—The Prison a comparatively Modern Institution—Torture—Barbarous Punishments of the Middle Ages—The Wheel, the Rack, the Thumbscrew, and the Boot—*Peine Forte et Dure*—The *Chambre à Crucer*, the Bernicles, the Gorget, the Mask—The "Baiser de la Vierge" of Baden-Baden—The Iron Coffin of Lissa—Louis XI.'s Iron Cage—The Tortures of the Inquisition—Mode of Procedure—The Rope Torture—The Trough and Water—Torture by Fire—The Auto-da-Fé—The "Maiden"—The Halifax Gibbet—The Guillotine—Minor Inventions of Punishment.

IN primitive ages, those who had the responsibility of enforcing law and order were swift and simple in their modes of punishment; they wasted not their time in devising instruments of deadly mechanism for the avenging of crimes, or in studying out nice gradations of guilt. Offences were easily classified, and as easily dealt with. The more serious violations of the law were answered by a short, sharp sentence of death; sword, rope, axe, or fire, being the aid most commonly invoked. Transgressions of a less heinous character were met by banishment, while minor lapses from duty were atoned for by public abasement and humiliation. It was left for civilisation to introduce the inventor to this gloomy sphere of operation, though, in justice it must be added, that in very few instances has the name of the contriver of any dread engine of punishment survived along with the object, or the memory of the object, of his invention. Ordinarily, what a man has invented is his glory and his pride; he wants all men to know what his skill has achieved and his patience brought forth; but it is not in human nature to be boastful of an association with Jack Ketch, let the link of connection be ever so slight.

Even the prison could scarcely be considered a recognised institution of ancient times. We read how "the princes were wroth with Jeremiah, and smote him, and put him in prison in the house of Jonathan the scribe: for they had made that the prison" (Jer. xxxvii. 15). And numerous instances are recorded of people being put in chains, and confined within stone walls for short periods, until the convenience of the law was served and judgment could be pronounced; but of systematic imprisonment, according to modern notions, or of punishment in which any particular ingenuity was displayed, there was little. The Greeks had places of public exposure, answering to the stocks or pillory of a later day; and both they and the Romans condemned criminals to labour in rowing galleys, and to the mines and quarries. The Mamertine vaults remain as the only historical evidence of an actual prison in ancient Rome; but this was a dungeon pure and simple where air and light could not penetrate, and where prisoners would simply die under an accumulation of fetid subterranean horrors if left to linger there for any lengthened period. Torture was resorted to both in Greece and Rome, it is true; indeed, it formed a recognised feature of the code of Justinian; but we must leave those far-back times, and search amongst the chronicles of the years of the Christian era, to discover that development of ideas of punishment which has brought the subject within the limits of a work treating of inventions.

In the sanguinary period of the Middle Ages there was not a single European State in which some description of torture did not prevail. England was the last country to adopt it, Edward II. being induced, in 1310, to have recourse to these barbarous methods of punishment in order to bring the Templars into subjection. From that time down to the last century, torture was more or less practised upon criminals and political offenders in the various countries of Europe, the system reaching its height under the cruel rule of the Inquisition, when inventions of the most horrible description were brought into use by the monks, and applied with a fiendish cruelty that it is impossible, by any process of extenuation, to associate with a true conception of the Christian doctrines of which they assumed themselves to be the leading apostles.

Prior to the Inquisition, the tortures of the wheel, the rack, the thumbscrew, and the boot, were those most commonly in use ; and there was the punishment of the *peine forte et dure* (the strong and hard pain), which was a kind of torture inflicted on those who refused to plead when put on their trial. This latter punishment was a piece of brutality which often proved too much for those who were submitted to it. The prisoner was taken into a low, dark chamber or vault, and there stripped naked and laid on his back on the floor. Then weight after weight of iron was placed upon him, being increased until he either pleaded or died, the only sustenance afforded him during the time of his suffering being a scanty supply of bread and water. Sir Walter Calverley, whose misdeeds form the subject of the "Yorkshire Tragedy," was put to this ordeal at York, but remained obstinate to the last, and died under the punishment. There was a prisoner who survived forty days of *peine forte et dure* in the reign of Edward III. So late as 1741 there is an instance of the infliction of this torture.

The rack was used in England up to the year 1640, and in the reigns of Mary and Elizabeth sufferers for conscience' sake and suspected witches were frequently put to this punishment. The instrument was of somewhat complicated construction, and consisted of a straight bar with teeth on its edge so as to gear with those of a wheel, pinion, or sector. A segment rack had its pitch line curved. Then there was a double rack motion, with double-barrelled air-pumps, and a spur-wheel, which being turned by a handle was made to impart a reciprocating sectilinear motion to each side, causing the most excruciating agony.

The thumbscrew, which enclosed the thumb in a tubular vice, and was acted upon by a screw, compressed the thumb with such force that the blood would start from beneath the nail. The "boot" was a species of torture that was formally recognised by the Scottish law. It was an iron instrument in which, after the leg was fixed, long wooden wedges were driven between the limb and the iron, until the culprit either fainted or confessed. It needed a stout heart in those days to resist acknowledging offences which had never been committed.

Amongst the other inventions of cruelty which it pleased the monarchs of Europe to exercise upon their victims in those days, were such special instruments of punishment as the "chambre à crucer," the "bernicles," the "gorget," and the "mask." The "chambre à crucer" consisted of a heavy chest, short, shallow, and lined with sharp stones. In this the offender was placed, and the lid was shut firmly down upon him, forcing his naked limbs into violent contact with the jagged points of the stones. The "bernicles" had a mattress for its foundation. Upon this soft couch the prisoner was fastened by the nape of the neck with bullocks' sinews, and then, when he had been so secured that he could not raise himself up, his legs were passed through a kind of stocks, and crushed between two great logs of wood, on the uppermost of which a man would sit until a sufficiently acute point of agony had been reached. The punishment was repeated on the third day, which, the old chronicler assures us, "was the cruelest thing that was ever heard of." The "gorget" was an instrument which was fitted to the neck, and imparted to the sufferer all the sensations of strangulation; and the "mask" was a fearful contrivance of steel bands, which were drawn across the face, and contracted tighter and tighter by means of a screw until every feature was pressed out of shape, and from beneath the metal bands there gushed a stream of blood.

Perhaps, however, the climax of torture was reached in the "baiser de la Vierge" of Baden-Baden and the "iron coffin" of Lissa. In the former, the culprit, blindfolded and fastened into a chair, was lowered by a windlass through a well-like shaft, reaching from the top of the castle deep down into the heart of the rock on which it stood. This shaft was so deep that scarcely a glimmering of daylight could be discerned at the top by those below. In this rayless depth there was a dungeon hewn out of the solid rock, and fitted with the door of the same material a foot thick, so artfully constructed that it was not to be distinguished from the surrounding wall. The helpless, blindfolded prisoner was immured in this cell until the hour of trial arrived, when, dazed and bewildered, he was brought before the judges who, masked and solemn, awaited him in the hall of judgment, which was a larger excavation in the stone. Not having confessed to the satisfaction of this mysterious tribunal, he was forthwith conducted to the torture-chamber, unbuckled from his iron bed, and directed to kiss a bronze statue of the Virgin, which stood at the end of one of the passages leading from the chamber, as the seal of whatever declaration had been wrung from him. As he raised his lips to the placid face of the Madonna, a trap-door suddenly gave way beneath his feet, and he was precipitated, fathoms down, upon a series of delicately poised wheels,

> "All horrent with projecting spurs,"

which his fall set in motion. The rest may be imagined. The "iron coffin" of Lissa was simply a contracting dungeon, such as Poe has described in one of his blood-curdling "Tales of Mystery." The prisoner whose fate it was to be consigned to this awful tomb, could see the walls closing in around him, nearer, nearer, day by day, the sides stealing steadily in upon him, and the roof creeping down, until at last they met and crushed the terror-stricken victim out of existence.

For exceptional victims there were exceptional punishments. Louis XI. used to derive exquisite pleasure from seeing his most hated of victims immured in iron cages, which were so maliciously contrived that it was impossible for the prisoners to put themselves in any position—sitting, standing, or lying—where they could obtain the slightest rest or comfort. In such cages of torment Cardinal Balue, and the son of the Duke of Alençon, were confined. Jornandi, a descendant of one of the Norman conquerors of Sicily, was seized by the Emperor, Henry VI., for rebellion, and enthroned naked on a seat of red-hot iron, and crowned with a similar diadem. Theodore Lascaris, annoyed that a noble matron of Constantinople had refused him the hand of her daughter, caused the lady to be stripped and enclosed to the neck in a sack along with a number of cats, who were pricked into the furious exercise of their teeth and talons by a couple of executioners. Justinian II. suspended offenders head downwards in the offensive smoke of a fire fed by noxious weeds.

Coming now to the malignant punishments invented by the heads of the Inquisition, we find all the older methods of torture revived and strengthened by a long list of new cruelties which have in them more of the infernal than anything the world has ever experienced. The demoniacal tortures inflicted in the name of religion at that time struck dismay into the heart of Europe. It would be an extravagant compliment to allude to the so-called holy Fathers who had the control of these things as fanatics. They were men possessed by the demon of hatred—hatred born of fear—and, impressed by the belief that the rival faith of Protestantism could be crushed by oppression, they brought into play against their opponents all the ingenuities of cruelty which the art of man could discover.

The Inquisition assumed to itself the right of judging (1) heretics; (2) those suspected of heresy;

(3) their abettors and protectors, and all persons who favoured them in any way whatever; (4) magicians, sorcerers, enchanters, and all those who made a practice of witchcraft; (5) blasphemers; and (6) those accused of resisting the officers of the Inquisition.

Giving their tribunal this wide scope of punishment, and laying themselves open to the interested accusations not only of their own officers, whose business it was to find offenders, but to the secret suggestions of private malice, no wonder that they filled their prisons and made wholesale sacrifices of victims. Their proceedings from first to last were marked by the most inhuman brutality.

When a prisoner was brought in he was mercifully exhorted to confess his iniquity; all his piteous appeals and protestations of innocence were contemptuously disregarded; and he was consigned to a dismal cell, after having had his hair cut off and being stripped of all he possessed, and there left to linger untried perhaps for months. He was asked at intervals if he had made up his mind to confess, and, after a time, grown a little tired of this hollow formality, the officers would proceed to set in motion the elaborate machinery of torture which the pious dignitaries of the Inquisition had planned for the extortion of self-condemnation. There were three principal kinds of torture. The first was by the rope, the second by the trough and water, and the third by fire. In the rope torture a rope was fastened to the hands of the accused, being previously tied behind his back; then he was raised into the air by a pulley to a considerable height; and after having been held suspended for a time, was suddenly let fall to within about half a foot of the ground, being stopped with a jolt that dislocated his joints and caused him to utter the most piercing cries of anguish. This was continued as long as the doctor of the Inquisition cared to certify the sufferer to be capable of bearing the torture. To make the punishment all the more horrible, the proceedings were conducted in a subterranean vault, by the lurid light of a couple of torches, the men whose task it was to execute these orders of butchery being clothed in black robes and black hoods that concealed the face, but had holes for the eyes, nose, and mouth.

If the rope torture did not suffice, the culprit was next submitted to the trough and water punishment. There was a large piece of timber made hollow like a trough, with a sharp iron bar across. The unfortunate prisoner was placed in the trough, his back supported by the bar, and his head and feet being fastened down by cords to the bottom of the trough, in which position, from the pressure of the bar and the dreadful tightness of the cords, he endured inexpressible agonies. Then, having stopped the nostrils of the victim, they placed a piece of linen cloth over his mouth, upon which they poured a stream of water from a considerable height. This forced the cloth deep into the throat of the sufferer, and by this means he was almost totally deprived of the power of breathing. They then occasionally removed the cloth to prevent the prisoner from expiring under his sufferings, which were again renewed as soon as the doctor pronounced him able to endure them.

The torture by fire was the most horrible of all. A fierce fire was lighted up, and having rubbed the feet of the prisoner with lard and other penetrating substances, they stretched him along the ground with his feet close to the flames, and in this position he was held until, unable to bear the horrible agony any longer, he would invent the confession necessary to secure the final punishment and release of death.

After confession had been wrung from the agonised sufferers, they were committed to the dungeons to await the Auto-da-Fé, when they were conducted in batches to the funeral pyres, where, surrounded by all the mockery of justice and religion, accompanied to the place of execution by a vast procession of monks, torchmen, pikemen, musketeers, and inquisitors, and their heads covered with pasteboard conical mitres, painted with flames and devils, with the words "sorcerer" and "heretic" written round the rim, they were burnt to death in the presence of the King and the court, the Grand Inquisitor, and a gay holiday crowd which found in this human holocaust a pleasure more diverting even than a bull-fight. The Inquisition did not wholly cease to exist until far into the last century, torture was continued in use in some countries almost down to our own day. It was abolished in France, curious to say, on the eve of the great Revolution, in 1789; in Germany in 1754, in Austria in 1776, and in Sweden in 1786; but such abolition was not always effectual, for we read that in 1782, a gang of gipsies, to the number of forty-eight, were put to the rack in Hungary on an unfounded charge of cannibalism; and even in more recent times Ferdinand VII. of Naples was accustomed to put exceptional prisoners to the torture of the "water question."

Turning to our own country we find, apart from such tortures as were imported from the criminal machinery of Continental nations, sundry inventions of punishment in use which demand a passing notice. There was in the Middle Ages a beheading machine in operation in certain localities, from which the notion of the French guillotine was probably borrowed. In Scotland this death-dealing apparatus was styled the Maiden; in England it was simply named the gibbet. There were points of difference between the various machines which went under these and other names, but these were so unimportant that a general description of one may suffice for all. In the town of Halifax, in Yorkshire, the local baronial lord exercised the privilege of the gibbet upon certain criminals apprehended within his liberty, and in the sixteenth century many persons suffered death on the Halifax gibbet-hill, which yet remains, with some of its ancient surroundings and machinery, as historical evidence of the rude punishments of those days. A local chronicler, writing in the early part of the last century, has thus described this peculiar custom of gibbet-execution:—

"After the felon had been found guilty, and declared so by the jury, he was not put to death instantly, but confined in prison for about a week; not only that he may have time to prepare for his latter end, but also to expose him openly to the world; for there being one general market day in the week, and two other days of more than common stirrings, the felon was on every one of those days set in the public stocks, with the goods he had stolen on his back, if he could carry them, but if not, they were placed before his eyes, that all passengers might see them. And this was done in terror to others, that they might take warning by his wicked deeds, never to commit the like. After he had been thus handled for about a week he was brought by the lord's bailiff to the place of execution, the scaffold now standing to this day. There was a peculiar engine framed for the purpose, the figure whereof may be seen in Bishop Gibson's Camden's 'Britannia.' In this engine the axe (which is yet to be seen at the bailiff's house) was drawn up by a pulley, and fastened with a pin to the side of the scaffold. If it were an horse or ox, or any other creature that was stolen, it was brought along to the gibbet, and fastened to the cord by a pin that stayed the block, so that when the time of execution came (which was known by one of the jurors holding up one of their fingers), the bailiff or his servant whipping the beast, the pin was plucked out, and execution done; but if it was not done by a beast, the bailiff or his servant cut the rope." This quaint writer adds, "'Tis supposed that this punishment has been the cause of the beggars putting this town into their litany: 'From Hell, Hull, and Halifax, good Lord, deliver us.' The first of these they may be thought to fear least, because of their wicked lives; Hull they pray against, because they meet with correction, the best charity; as also they do at Halifax, where theft, which they use so much, meets with so quick a punishment." The last persons to suffer death by the gibbet at Halifax were executed in 1650.

From this it is but natural we should pass to the improved gibbet which, since the time of the Revolution, has done duty in France as the instrument of death—the guillotine. Here, at last, we have an invention of punishment associated with a name and an individual, but, unfortunately, the connection is one that has to a certain extent been misapplied. Dr. Joseph Ignace Guillotin, who was a member of the National Assembly, made two propositions to that body. One was that the punishment of death should be the same for criminals of all ranks, up to that time nobles and privileged persons having the choice, when condemned to death, of being decapitated either by the axe or the sword, while the common people had to be content with the hempen rope. This suggestion was adopted. He likewise proposed that decapitation should be the only method of execution, and that, instead of the clumsy axe or sword, which left so much to the executioner, and often led to scenes of terrible horror, there should be adopted some machine which should be provided with a heavy knife that would descend upon the neck of the criminal and sever the head from the body almost without pain.

This suggestion was under consideration for a year or two, during which time Dr. Antoine Louis, secretary of the Paris College of Surgeons, was instructed to report upon the matter and advise the Assembly what sort of beheading machine would best serve the purpose. He subsequently was able to explain that the notion had already been carried out in various places; that a machine called the mannaja had been in use in Italy in the sixteenth century; that some such apparatus was employed in Languedoc for beheading Duc Henri de Montmorenci in 1632; and that in the North of England and in Scotland and Persia machines of a like character had been used. A committee was formed to consider the question, and Dr. Louis, Dr. Guillotin, Sanson, the executioner, and a German musical-instrument maker named

Schmidt, consulted together upon the best means of giving effect to the desire for a new machine of decapitation. It is said that the King himself, who had a taste for lock-making and invention, had a hand in the business, and suggested an improvement which was practically adopted. After the designs had been agreed upon, Guidon, the carpenter, constructed the required machine, for which he was paid a sum of 5,500 francs. First of all, the apparatus was tried upon the dead bodies of three men and some live animals at the prison of the Bicêtre; but the first real victim of the guillotine was a highwayman named Pelletier, who suffered execution on the 25th of April, 1792. Dr. Louis, the chief inventor or adaptor of the guillotine, did not live to see the dread machine put to the terrible strain which followed when the Revolution became so murderous in its work. Dr. Guillotin lived on, however, and, in spite of all that he could do to prevent it, had to bear the degradation of having his name perpetuated in connection with the instrument, though he was spared the worst pain of all—that of being put to death by the machine that was called after him. He was very near coming to this pass in the days of the Terror, being thrown into prison as a "suspect," and, but for the timely downfall of Robespierre, would no doubt have had to submit his head to the fatal knife. It was sought to connect the name of Dr. Louis with the invention, and such titles as the "Louisette" and the "Louison" were proposed; but in the popular mind the name of Dr. Guillotin was indelibly fixed as the original proposer of the machine, and the guillotine it was called and will continue to be called to the end. How much the doctor himself disapproved of the connection may be gathered from the fact that in an Autobiography which he wrote he did not make the least mention of the guillotine. In the six weeks preceding the death of Robespierre, this historic machine took off the heads of upwards of eleven hundred victims.

It is almost a pleasure to turn from a ghastly record like this to the minor inventions of punishment used in the olden time. Of the hangings and beheadings we need not speak, since, with the exception to which we have referred, they did not show any inventive feature; nor need we linger over the Hurdle, which the monks suggested in substitution for the dragging of a victim at the tail of a horse over the stones and through the mud on his way to execution. The Pillory was a more ordinary instrument of punishment and existed amongst our Saxon ancestors in the form of what was called a stretch-neck, but in the time of Edward I. it underwent certain alterations of construction which made it much the same in shape as the pillory which was in general use down to very recent times. It was not until 1837 that it was abolished by Act of Parliament. Defoe, who was himself placed in the pillory more than once, has addressed a hymn to this instrument of degradation, which he thus invokes:—

> "Hail, hieroglyphic State machine,
> Contriv'd to punish fancy in;
> Men that *are* men, in thee can feel no pain,
> And all thy insignificants disdain."

The Stocks have survived from the earliest times of which we have any record, and are still occasionally used in country towns. The Whipping-post was at one period a very familiar object in England. Taylor, the "water-poet," writing in 1630, says:—

"In London, and within a mile, I ween,
There are jails and prisons full eighteen,
And *sixty whipping-posts*, and stocks and cages."

At Coteshill there is a formidable engine of punishment still standing, which is stocks, whipping-post, and pillory, all in one. Then there was the Ducking-stool for the correction of scolds. This instrument consisted of a sort of chair at the end of a plank, which was worked upon an axle, the offender being secured in the chair and then let down into the water, where she was ducked until her punishers were satisfied. In "Hudibras" we read:—

"These mounted on a chair curule,
Which moderns call a cucking-stool,
March proudly to the river side,
And o'er the waves in triumph ride.
Like 'Dukes of Venice,' who are said
The Adriatic Sea to wed,
And have a gentler wife than those
For whom the State decrees these shows."

The Tumbrell consisted of a chair, a pair of wheels, two long shafts, and a rope attached to each shaft. The culprit was placed in the chair and dragged round the streets amidst the jeers and hootings of the populace. In some cases it formed a ducking-stool as well. The Brank, or Gossip's Bridle, was a framework of iron which was placed round the head of the offending woman, and acted as a gag upon her tongue. Of these instruments of mild torture there are many specimens existing in different parts of England; and in some countries of the East they still retain in use many curious inventions of torment which the civilisation of the West has either rejected or discarded. Invention in this day has little concern, however, with matters of punishment. The hangman and his rope serve for the extreme sentences of the law in Great Britain, while lesser offences are completely covered by our prison system. And so a point of effective justice is reached at which invention may, with good grace, take its leave of a connection that, all things considered, has hardly yielded it honour or distinction.

CHAPTER XIII.

COSTLY MACHINERY.

The Combing Machine—Great Outlay of Experimenting Inventors—Dr. Cartwright's Wool-combing Machine—Platt and Collier—Mr. G. E. Donisthorpe—Mr. S. C. Lister takes up the Idea—Heilmann's Machine—Patent-right Disputes—Heilmann's Right is Bought Up—Mr. Isaac Holden—Great Wool-combing Operations in France—The "Square" Motion—A Perfect Piece of Mechanism—Mr. Lister Buys a Heap of "Rubbish"—His Experiments with Silk Waste—A Great Idea—A Ten Years' Task—The Silk Waste Manufacture ultimately Established—A New Industry—Sir Henry Bessemer—His Early Inventions—Receives a Commission from Napoleon III.—Begins Experimenting in Metals—His Great Discovery—Prejudice of Steel-Makers—Establishes his own Steel Works—Steel Rails—Bessemer knighted.

THE inventions of greatest cost are probably the dread machines of war, for no outlay is considered too much for a killing machine, if there is only the likelihood of its being more destructive than any other invention of a similar description. Our present inquiry, however, is in respect of machines properly so called, not weapons of warfare. All machines for mechanical purposes are costly, to begin with,—costly in time, costly in money, costly in protecting; while some of the inventions connected with metallurgical processes require the expenditure of fabulous sums before they can be brought to perfection.

One of the costliest of single inventions has been the combing machine, which from its inception to its latest development, from its small beginnings in connection with the manipulation of wool to its ultimate application to all the principal textile industries, has absorbed, as well as made, scores of fortunes. In respect of wool-combing alone, it is estimated that experimenting inventors have expended more than £2,000,000 sterling. Mr. S. C. Lister, one of the names most intimately associated with the wool-combing machine, has himself spent several hundred thousand pounds in the various inventions of this class with which he has been concerned; and Mr. Isaac Holden, another prominent worker in this field of invention, has invested no less than £50,000 in wool-combing improvements. Joshua Heilmann, who introduced a wool-combing machine in 1846, and had it patented in France and England, received £80,000 from firms in this country for his English patent rights. Mr. Lister paid him £30,000 for the rights as far as regarded the worsted trade; six Lancashire firms subscribed a similar sum for the same privileges for the cotton manufacture; and Messrs. Marshall, of Leeds, gave £20,000 for liberty to use the invention in the flax industry. These figures in themselves will suffice to indicate the magnitude of the prize to be competed for.

From the end of the eighteenth century the idea of a combing machine had occupied the minds of inventors. Dr. Cartwright, the inventor of the power-loom, had taken a patent out for wool-combing by machinery in 1790, but it came to nothing. Three or four years later, Mr. Robert Ramsbotham had erected a combing machine in Bradford, but his experiments were of such an unsatisfactory character that he at last had it carted away, and, taking his hat off to it as it disappeared, wished it a very good day. Nothing more was done until 1827, when Messrs. Platt and Collier introduced a new combing machine, which was a great improvement upon anything of the kind that had up to that time been invented. Still, it was believed by many that it was impossible to produce a machine that would be able to perform the delicate operations of combing as well as they could be done by hand. The hand-combers themselves laughed at the notion. These artisans were numbered by the thousand in the town of Bradford, the head-quarters of the worsted trade, and from time to time showed their strength and influence in commemorative festivals in honour of Bishop Blaize, their patron saint, who is said to have invented the art of wool-combing in the reign of Diocletian. The last of these trade pageants was held in 1825, two years before the introduction of Platt and Collier's machine, which invention, much as it was in advance of previous machines, was yet far from the point of acceptability. But the idea had taken root in many minds, and inventors in England, France, and America were actively engaged in attempting to work out the problem. Mr. George Edmond Donisthorpe succeeded in improving upon the machine of Messrs. Platt and Collier, and it was by having his attention drawn to this improvement that Mr. Lister was first induced to enter this promising field of enterprise. Mr. Lister thought he perceived in Mr. Donisthorpe's invention the germ of such a machine as would effectually supersede the labour of the hand-comber. Being already successfully established in business as a manufacturer, he invited Mr. Donisthorpe to join him as partner, and, the offer being accepted, the two were free to pursue their labours on the wool-combing machine together, which they did with rare energy and ability for many years. After long and patient toil they ultimately reached the goal at which they had been so persistently aiming, and gave to the trade a machine which, though still imperfect, was capable of accomplishing the combing process with such a degree of success as to render the manual operation no longer necessary.

During all this time, Joshua Heilmann, in France, was working to the same end. He was not less enamoured of his idea than Lister and Donisthorpe were of theirs; but he was less fortunately circumstanced than they, for while they had ample means at command, his own were completely exhausted. Dr. Smiles has told us, and Mr. Elmore has pictured for us, how, one night, while Heilmann was sitting by his hearth, "meditating upon the hard fate of inventors, and the misfortunes in which their families so often became involved, he found himself almost unconsciously watching his daughters combing their long hair and drawing it out at full length between their fingers. The thought suddenly struck him that if he could successfully imitate in a machine the process of combing out the longest hair, and forcing back the short by reversing the action of the comb, it might serve to extricate him from his difficulty. . . . . Upon this idea he proceeded, introduced the apparently simple but really most intricate process of machine-combing; and after great labour he succeeded in perfecting the invention."

It is still a disputed point as to who was really the first to bring the combing machine into practical working condition. Mr. Lister has himself had something to say on this question. On a certain public occasion, referring to the wool-combing invention, he said, "I have received, perhaps, more than my fair share of credit for that machine. I have always wished to do justice to those associated with me;

and Mr. Donisthorpe and myself were, I consider, the parties who mastered the difficulty. I am not jealous as to the antagonism of English inventors, but I am anxious that Englishmen should have the credit of that invention. Some people have put Mr. Heilmann forward as the inventor of the combing machine; but before Mr. Heilmann's patent was heard of we had succeeded in mastering all the difficulties connected with the invention. I, therefore, claim the combing machine, as well as the spinning machine, as an English invention. I do not claim it for myself; I only claim that I am entitled to a fair share of credit for its success."

Unfortunately, Messrs. Lister and Donisthorpe did not take out the patent for their machine quite so soon as they might have done, and Heilmann having obtained an English patent before them, in 1846, he was able, when the question came to be argued out in the courts of law, to get a decision in his own favour. After this, as we have seen, Mr. Lister bought Heilmann's patent so far as it would be likely to come into competition with his own ; but to substantiate his view of the matter—that Heilmann's machine was inferior to his—Mr. Lister did not attempt to bring the French machine into use, but stuck to his own, to which he and those associated with him added many important improvements.

Nearly all the men who have helped the machine forward in any marked degree have been connected with Mr. Lister more or less. Mr. Isaac Holden offered suggestions to Mr. Lister, in 1846, for improvements, which were patented in their joint names. It was under Mr. Holden's advice, too, that Lister's machine was afterwards introduced into France, and in 1848 a combing concern was established in that country—first at St. Denis, and afterwards at Croix, near Roubaix, and at Rheims—under the firm of "Holden and Lister," Mr. Holden accepting the position of managing partner. About this time what is called the "square motion" combing machine was brought forward, a machine which Mr. Holden claims mainly to have originated; and this he so altered and improved, that when, in 1859, the partnership between Mr. Lister and Mr. Holden was dissolved, and the latter continued the French establishments in co-operation with his two sons, Mr. Angus Holden and Mr. Edward Holden, it was this "square motion" combing machine, in which the action of the hand-comber was imitated as closely as possible, that was made to supersede the other machines. This firm of wool-combers have for many years carried on the largest wool-combing businesses both in France and in England. Other names are entitled to prominent mention in connection with this great machine. Mr. Noble and Mr. Hubner introduced important improvements. Both Mr. Lister and Mr. Holden made enormous sums by the combing machine. The former used to receive as much as £1,000 per machine as patent right; and as the machines were in general use by the trade, his income in royalties alone must for many years have been almost fabulous. Mr. Holden kept the "square motion" machine chiefly to himself, and, therefore, did not reap the reward of patent rights that Mr. Lister did; still, while Mr. Lister sought other fields of mechanical enterprise, Mr. Holden adhered to his wool-combing with a steadfastness that won complete success, and yielded results quite as wonderful as those which fell to Mr. Lister. The story of the wool-combing machine, indeed, is one in which the power of the capitalist has been exemplified no less than the genius of the inventor. It cost more to complete, and yielded more when complete, than any other single machine of the century, and is, perhaps, the most perfect piece of mechanism to be found in all the range of the textile industries of this country. Its work is to take up the raw wool, comb the fibres dexterously and smoothly out, place them exactly parallel with each other, separate the long fibres from the short, and draw out the former into one united "sliver," in which condition it is ready to be submitted to the spinning process. All this it performs with the minimum of manual aid, the only thing that it requires being to be fed with the raw wool; when once it gets it within its teeth, all the rest is automatic, precise, and perfect.

Another costly series of inventions with which the name of Mr. S. C. Lister is identified may be mentioned. These are the machines which were necessary for the creation of the manufacture of silk waste, an industry which Mr. Lister originated, and for a period kept in his own hands. At one time, Mr. Lister was out of pocket to the extent of £360,000 by his efforts in this direction, and, to use his own expression, he "wrote off" a quarter of a million as entirely lost before he began to make up his books again. The prize to be striven for, however, was again a gigantic one; the inventor had an object worthy of his genius. The manner in which this great idea originated was somewhat curious, the incident being almost parallel with that of the discovery of alpaca by Sir Titus Salt. Business took Mr. Lister into a certain London warehouse one day, now many years ago, and in his wanderings about the place he came upon a heap of rubbish, the precise nature of which he did not comprehend. Inquisitive in all things pertaining to trade, he asked what it was, and was informed that it was merely a pile of silk waste. "Silk waste!" he said; "what do you do with it?" "Sell it for rubbish," was the answer; "that is all that it is good for." And, certainly, that did seem to be about the truth of the matter, for anything more unpleasant to the eye or more disagreeable to the smell it would have been difficult to imagine. It was nothing more or better than a mass of knotty, dirty, impure stuff, consisting of the waste made from the manufacture of neat silk and pierced cocoons, and looked like mutilated ropes, unclean flocks, or mucilaginous hemp, and was choked with sticks and leaves, and dead silkworms. But unwholesome and offensive as it seemed, it set Mr. Lister's imagination at work, and bred in him such dreams and fancies that he could not pass it by. He tumbled it about, handled it, and partially disentangled a few handfuls of it, and wound up by making an offer of a halfpenny a pound for the "rubbish." The offer was gladly accepted, and in due course the silk waste found its way to Manningham Mills.

Up to this time Mr. Lister had confined his energies solely to the processes of the worsted trade; of the silk trade or silk machinery he knew little or nothing. While the heap of waste lay in his warehouse awaiting his decision regarding it, however, he set himself to acquire a full knowledge of the condition of the silk manufacture both at home and abroad. Nowhere could he find that any attempt had been made to utilise silk waste. All the world over it was treated—

as he had seen it treated in the London warehouse—as "rubbish." This was exactly what he wanted, so, without more ado, he turned to his heap of waste and made the resolve that he would invent a set of machines that should be powerful enough to manipulate this refuse into fabrics that should vie in beauty with the brilliant goods manufactured from the perfect cocoon. In this enterprise he was not beset by rivals, as he had been in the days of struggle with the wool-combing machine; he had this time taken a thing in hand in which no one but himself felt the shadow of an interest, and he could work on in peace without being haunted by the fear of some one stepping in between him and success. For fully ten years did he devote himself to his stupendous task before he arrived at any tangible result.

To begin with, he got from the silk districts of the Continent a number of workmen thoroughly skilled in the construction of silk machinery and acquainted with all the processes of the established manufacture, and, with their help, entered upon a series of experiments of almost unequalled extent. For a long time these workmen viewed their employer's operations with suspicion and distrust, but as obstacle after obstacle was surmounted, they began to think Mr. Lister's idea had, after all, "something in it." The outside world all the while knew little of the mighty plans that were slowly but surely maturing in the secret rooms of Manningham Mills; it was known that Mr. Lister had permitted the wool-combing business to leave his grasp and spread itself generally over the worsted district, he retaining the full rights and royalties of his patents; and it was known that Mr. Lister's losses and expenditure on his inventions had seriously crippled his resources; but no one but himself could see what a magnificent dream was presently to be fulfilled. In connection with his silk waste schemes, Mr. Lister had to bring to perfection many new machines, some of them of gigantic proportions; he had also to introduce a new loom for the weaving of the velvet which he proposed to produce from the silk waste when the whole of his system was complete. He purchased the patent right of a velvet loom invented by Mr. Reixach, a Spaniard, and engaged the inventor's son to assist in its adaptation to his requirements. It took a year or two to bring the loom up to Mr. Lister's idea; but this was eventually accomplished, and the machine in its present form is considered to be perhaps Mr. Lister's greatest mechanical achievement. The loom weaves two pieces of velvet simultaneously.

It was not until 1865 that Mr. Lister finished his task. In that year he was able to show to the world an entirely new industry, for the accommodation of which he afterwards erected factories of an extent previously unknown, comprising sixteen acres of flooring, and affording employment for about four thousand persons. The whole thing was so new that the "hands" had to be taught over again, each weaver costing the firm many pounds sterling before she had mastered the difficulties of her new occupation. From the once despised silk waste there now came to be manufactured a rare variety of fabrics, little inferior to the goods made from pure silk—velvets, plushes, poplins, silk carpets, sewing silks, and what not. The result was that silk goods were greatly cheapened, and new classes of textiles were put on the market, many of which speedily gained the hall-mark of fashion. To Mr. Lister's later enterprise the world owes most of the rich and inexpensive plushes which in recent years have been held in such high esteem. He staked his fortune on the undertaking, as he had previously done in regard to the wool-combing, and, as his reward, fortune has returned to him many times over. Silk waste, that was formerly worth next to nothing, has now a value in the market, and the world is all the richer for the skilful manner in which Mr. Lister has utilised it.

Perhaps no inventor of modern times has experimented in iron on a scale of equal magnitude to Sir Henry Bessemer. Certainly no inventor has by his own efforts added so largely to the resources of the world, or effected so great a saving in the cost of production of a leading commodity. Many inventions are to be placed to the credit of this indomitable worker, but it is by his method of steel-making that he will be principally remembered. He has founded a manufacture that is worth £20,000,000 a year, and reduced the cost of steel to a fraction of what it was in former times. In the manufacture of steel rails alone it is estimated that Bessemer's invention has effected a saving of a capital sum of something like £200,000,000. These are such big figures that beside them the statement that the inventor received as his share of the benefits of his invention the sum of £1,057,748 seems almost small.

Henry Bessemer was a born inventor. In his youthful days he occupied himself much with stamps and dies, and was at one time actually promised the post of superintendent of stamps, at a salary of £600 or £800 per annum for an invention which the Government of the day decided to adopt; and this arrangement might have been carried into effect had not Bessemer knocked the whole thing on the head by suddenly devising a system by which all the old organisation could be utilised to the same purpose with but little change or expense. For this he never received fee or reward of any kind. Presently he turned his attention to larger enterprises, and during the time of the Crimean War invented a mode of firing elongated projectiles from a smooth-bore gun. The British Government declined to have anything to do with the invention, so he tried the Emperor of the French with it, and that monarch gave Bessemer a commission to make a number of experimental projectiles according to his plan. These were subsequently tried at Vincennes, under the direction of Commander Minié, who, while approving of the projectiles, said that something stronger than cast-iron would be required for the guns if they were to be of proper service. This suggestion, casually thrown out, gave Bessemer the cue to experiment in metals for artillery purposes; and although at the time comparatively ignorant of metallurgical processes, he soon not only mastered the whole subject, but, in his works at St. Pancras, advanced far beyond the scope of ordinary experiments. He succeeded within a year in greatly improving the quality of cast-iron, and made a small gun from his superior metal, which he presented to Louis Napoleon.

Bessemer zealously continued his experiments, though the cost of them nearly ruined him. He had made clear the great fact "that the refinement of iron in the fluid state might go on until pure malleable iron or steel could be obtained." So matters went on until, in 1856, he read a paper at the British Association meeting at Cheltenham "on the manufacture of malleable iron and steel without fuel," which set the iron trade in a flutter of excitement. Within thirty days of his reading that paper he received a sum of £27,000 from leading ironmasters for licences to use his invention, but so convinced was he of the ultimate value of his idea that he afterwards paid £31,500 to rescind the licences. He was still, however, far from being in smooth waters. The earlier results obtained by the new process were disappointing, the metal produced by it was of unsatisfactory quality. It was found that, though silicon and carbon were effectually removed from the iron by the process, a large percentage of sulphur and phosphorus remained. At this juncture, Mr. Mushet suggested the addition of manganese to the contents of the converter as a means of remedying the defect, and this was acted upon with the most gratifying success, the manganese being supplied through the medium of a due proportion of *spiegeleisen*, a white hard cast iron containing about ten per cent. of manganese. Until this had been accomplished, Bessemer was regarded by the trade as a defeated inventor, and underwent a period of very bitter trial. His friends had implored him to desist from the pursuit of an impossibility.

At last, success crowned his efforts, and he had the delight of seeing produced by his furnace bars of good, bright, pure steel. In the market the value of steel of that quality was at that time from £50 to £60 per ton. It had cost him in the conversion about £7 per ton. This was indeed a revolution. He took some of the bars to the works of Messrs. Galloway, at Manchester, and for two months it was given out in the regular way, and the workmen had not the slightest notion that they were not using ordinary steel of the best quality. The Sheffield steel-makers were still unfavourable to its adoption unless they could arrange for a monopoly of it, so, in defiance of them, Bessemer established steel-works of his own in the town, and was soon in the market with his new metal, selling it at from £10 to £15 per ton below his rivals' prices. But the invention was of too great importance to be kept back; not only did Bessemer's own concern flourish, but his invention was adopted in all the principal iron districts of the world. The Bessemer Steel and Ordnance Works were subsequently established at East Greenwich, and Bessemer steel was introduced as a substitute for iron for rails. It is related that when Bessemer first proposed steel rails to Mr. Ramsbottom, the engineer of the London and North-Western Railway, the latter indignantly demanded if the inventor wished to see him tried for manslaughter. Steel rails, for all that, not long afterwards were introduced on all the leading lines, and at no distant period there will not be an iron rail left. In cheapness, durability, and smoothness steel rails are far to be preferred to the original iron rail. A man who has by his inventive genius and pluck done so much for his country, and achieved so high a position for himself, is deserving of all honour; and the dignity of knighthood which the Queen conferred upon him in recognition of his services to one of the leading industries was no more than his due.

CHAPTER XIV.

INVENTORS IN TOYLAND.

Puppets — Marionettes and Automata — Marvels of the Middle Ages—Albert Magnus and his "Speaking Head"—The Oracles of Pagan Times — Faber's Euphonia — The Marquis of Worcester's Artificial Horse—The Automaton Group of Philip Camuz—Jacques Vaucanson, the King of Automata Constructors—His Early Experiments—The Celebrated Flute Player—Automatic Animals—The Mechanical Asp—Maetzel and his Musical Automata—Writing Automata—Mechanical Puppets—Van Kempelin's Chess Player—Modern Automata.

INVENTORS have wasted much time in toyland, from the days of Vulcan downwards. Such marvellous results have been achieved in the shape of playthings, indeed, that it is only fair to infer that the ability which has produced such results might, if it had been turned to more useful account, have solved mechanical mysteries of real importance. We know that in more than one instance toy inventions have been the means of suggesting other inventions, which have proved of great service to the processes of manufacture, and that toys have frequently been pressed into the service of science. In some cases, inventors have given themselves up solely to the attractions of toyland; while in others, men of mechanical genius have simply resorted to the making of scientific toys as a relief to the sterner labour upon which their best energies were being exerted.

Toys of ingenious construction found much favour in the eyes of the ancients. Puppets, or *marionettes*, were patronised both by the Greeks and the Romans, and are frequently mentioned in the classic literature of the two nations. From *marionettes* to *automata* would be but a step, and there is abundant evidence that that step was taken at a very early period. The story of Vulcan and his tripods, which were supplied with wheels, and advanced and retired just as was required of them, descends to us with the stamp of Homer's authority. Then, did not Dædalus make moving statues; and does not Aristotle tell of a wooden Venus, that was set in motion by the action of quicksilver? Archytas, of Tarentum, too, by whom we get at an actual date—400 B.C.—has been handed down as the inventor of a wooden pigeon that could fly in the air; and though Beckmann is inclined to doubt the tale, the feat has been frequently performed with a child's toy in recent times.

It is not, however, until we get to the Middle Ages that we chance upon anything further of moment in the shape of automata, and then marvels crowd upon us thick and fast. Regiomontanus, who lived in the fifteenth century, is said to have made, first of all, an iron fly which would course hither and thither with as much ease as if it had been made of feathers instead of metal; but his crowning effort was an automatic eagle, which, on the arrival of the Emperor Maximilian at Nuremberg, flew forth to meet him. Albertus Magnus, if the story is to be credited, achieved even a greater marvel than this, employing himself in the intervals of alchemical and other research in constructing a head that not only moved but spoke. It is added that Thomas Aquinas was so frightened at the sight of this head that he broke it to pieces, causing Albertus to exclaim, "So perishes the work of thirty years!" Another worker in the field of chemical experiment, no less a person than our own Roger Bacon, made a speaking head of brass, which excited the awe and wonder of all who heard it.

Speaking automata have been since then many times attempted by various mechanicians; but the difficulty of simulating the human voice is evidently too great for the attainment of complete success. The head of Orpheus was said to speak on the island of Lesbos. It is known that in pagan times the priests supported their superstitious teachings by pretended oracular deliverances from the mouths of statues, some of the figures being hollow and placed against the wall in such a manner that "a priest could slip unperceived behind them, and speak to the ignorant populace through their mouths." Most of the speaking heads, figures, and machines of a later date have doubtless had to be aided by trick in the same way, though several honest attempts to arrive at these results by proper automatic processes have been made. A speaking head was introduced to the court of Charles II., and greatly amused the frivolous monarch by giving answers to questions that were put to it; but when it was discovered by one of the pages that it was "a Popish priest" in the adjoining chamber, "who answered in the same language through a pipe the questions proposed to the wooden head by whispering into its ear," Thomas Irson, the exhibitor of the object, was dismissed from the royal presence. The most successful of the genuine efforts at producing a speaking automaton was perhaps that of Professor Faber, of Vienna, which was exhibited in London some forty years ago under the name of the Euphonia. Faber is said to have worked five-and-twenty years at this figure, and to have endeavoured, "by the anatomical and physiological study of the structures that contribute to the human voice, to attain to an imitation of that organ as regards both sound and articulation." There was no doubt the figure did enunciate words in a manner to be understood, and also sang. There was an arrangement of bellows-pipes, pedals, and keys, which the inventor played to "prompt the discourse" of his automaton, but there was no concealment or trick practised.

Willars de Honecort, who lived in the thirteenth century, constructed the figure of an angel that would "always point with his finger to the sun;" and the Marquis of Worcester, who confronts us at almost every step of our search through the scattered history of inventions, had amongst his perfected contrivances "an artificial horse, with a saddle and caparisons fit for running at the ring, on which a man being mounted, with his lance in his hand, he can at pleasure make him start, and swiftly to run his career, using the decent posture with *bon grâce*, may take the ring as handsomely, and running as swiftly as if he rode upon a barbe." But this did not come up to the automaton group invented by Philip Camuz for the diversion of Louis XIV. This consisted of a coach and horses, which would start off with a crack of the coachman's whip, and run merrily along, the horses prancing, trotting, and galloping in turn, and at last slackening and stopping in front of the King. Immediately the equipage had come to a stand a toy footman dismounted from the footboard, opened the door and handed out a lady, "with *bon grâce*," as the Marquis of Worcester would have said, who made a polite curtsey, presented a petition to his Majesty, re-entered the carriage, and the footman jumped up behind again, the coachman cracked his whip once more, and away the horses went, prancing, trotting, and galloping just as they had done before. Camuz had taken the measure of the Grand Monarque's intellect with much accuracy, and was no doubt well rewarded for his pains. Then there was another Frenchman, General De Gennes, who, having defended the colony of St. Christopher against the English, about the year 1688, amused himself with the more peaceful occupation of constructing an automaton peacock, which used to walk about in all its pride of extended feathers, pick up corn from the ground, and swallow it.

The king of automata constructors was Jacques Vaucanson, who was born at Grenoble in 1709, and while quite a boy invented some marvellous self-moving figures and machines. The bent of his mind was determined by a rather peculiar circumstance. On one occasion, having accompanied his mother to the house of a friend, and being left to himself, he perceived, through the crack of a partition wall, an old clock, with its slowly swinging pendulum ticking off the seconds of time. He watched the movements of the clock with curious eagerness, and did not rest satisfied until he had mastered the details of its mechanism. He took a pencil with him the next time he went, and drew a plan on paper of as much of the clock as he could see through the crack in the wall. Little by little he grew to understand the working of it, and one day suddenly caught the notion of the escapement movement, and, with some pieces of wood and such rough tools as he possessed, succeeded in making a clock of his own, that kept time fairly well.

Then began his experiments in automata. First of all he made a little wooden chapel, with figures in the garb of priests moving round it and wooden angels flapping their wings above it. Some time after this, while on a visit to Lyons, he heard that the municipality of that city were anxious to procure a hydraulic machine capable of supplying the whole city with water. He set to work and invented such a machine, and although he had not the courage to present it to the authorities when he had finished it, he not long afterwards discovered that there was a machine of a very similar construction called the *samaritaine* in operation in Paris. This confirmed him in his belief in his inventive capacity, and from that time forward he devoted himself to the study of those branches of knowledge—anatomy, music, and mechanics—which were best calculated to assist him in the course of invention he had determined upon—that of making automata.

Vaucanson's first great achievement in this direction was his celebrated Flute Player, which was one of the wonders of his time. It was the ambition of his life to construct an automaton of this description; but an uncle, to whom he owed much in the way of duty, endeavoured to dissuade him from the project. Being overtaken by an illness, however, which confined him for a considerable time to the house, Vaucanson employed the hours of his convalescence in making his ingenious machine, unknown to his relative. In order to conceal his operations as far as possible, he had each portion of the mechanism placed in the hands of a different workman, and as the pieces were returned to him he put them skilfully together, crawling out of bed to do it, by the aid of a faithful servant, who was in the secret. At

VAUCANSON'S FLUTE-PLAYER.

length the figure was finished, and, supported by the servant, he wound up the mechanism and set it going. As soon as the music began to issue from the flute, the servant fell on his knees before his master; but Vaucanson lifted him up, and while the automaton flute-player played his first tune they both embraced and wept for joy. According to D'Alembert, this remarkable figure stood on a pedestal, in which a portion of the mechanism was hidden, and, not only blew into the flute, but, with its lips, increased or diminished the tones it forced out of the instrument, performing the legato and staccato passages to perfection, and fingering with complete accuracy. This flute-player was exhibited in Paris in 1738, and made a great sensation.

Encouraged by his success, and no longer in fear of his uncle's ridicule, he employed himself upon other automata, and produced the figure of a pastoral flageolet player which played the wind instrument with one hand and beat a tambourine with the other. After this he set himself the task of imitating animals by means of automatic mechanism, and constructed a duck which was almost an exact imitation of nature in every detail, down to its very digestion. Like the peacock of De Gennes, it moved about in search of grain, picked it up with its bill, and swallowed it. It waddled, and swam, and dived, and quacked, for all the world like a real live fowl, and was altogether the most wonderful imitation of an aquatic bird that was ever seen. He afterwards made automatic impersonations of other living creatures—insects, beasts, and reptiles. To oblige Marmontel, when that author's tragedy of *Cleopatra* was brought out, he constructed a mechanical asp for the use of the heroine in the play, so that the closest possible resemblance to nature might be ensured. When the proper moment arrived the asp was brought forth, hissing and darting out its sting, and the tragedy was concluded with great realistic effect by the artificial mechanism so cunningly wrought by Vaucanson. A clever *bon mot* arose from this circumstance. Some wag was asked his opinion of the tragedy, and his reply was, "I am of the opinion of the asp!" Many other ingenious figures were from time to time planned by this clever Frenchman, amongst them a figure in which the circulation of the blood was simulated. This last contrivance was made to please Louis XIV., but for some reason was never fully completed.

Vaucanson's remarkable skill brought him much into notice. He refused an offer made to him by the King of Prussia to accept a position in the Court *entourage* at Berlin; but he did not decline to accept the post of inspector of silk manufactures which Cardinal Fleury placed at his service. He now turned his attention to the useful arts, and, while fulfilling his official duties in the silk districts of Lyons, invented machinery for improving the manufacture of that article. The workpeople were immediately up in arms against him, and a riotous mob pursued him with stones on one occasion and drove him out of the city. He revenged himself for this insult by constructing, in addition to the machine which had excited the anger of the operatives, an automaton ass to work the machine.

Not much more remained for Vaucanson to do, unfortunately. Voltaire celebrated his achievements in verse, comparing him to Prometheus; the King honoured him with his attention; and the public worshipped him, except those poor misguided silk-weavers in Lyons. But neither fame nor fortune could much avail him now; he was stricken down with disease, and was lost to the world for the rest of his days. But the ruling passion clung to him even in his final moments. He conceived the notion of constructing an endless chain, and, feeling the approach of death, was constantly urging his workmen to lose no time lest he should not live long enough to explain the whole of his idea. The endless chain for him was eternity. He died in November, 1782, and bequeathed his collection of machines to the King.

Maetzel, the inventor of the metronome, was another successful worker in the manufacture of musical automata. At Vienna, in 1809, he opened an exhibition, with a life-size automaton trumpeter as the chief attraction. When the audience entered, all they perceived was a tent. After a time the curtains parted and Maetzel appeared, leading forward the trumpeter dressed in the full regimentals of an Austrian dragoon. There was silence for a moment, then Maetzel pressed the left epaulet of the figure, and straightway the trumpet began to emit sounds of great power and sweetness. It gave the cavalry calls, played a march and an allegro by Weigl, accompanied by a full band of living musicians. Nor was this all. The figure then retired, and shortly reappeared attired as a trumpeter of the French guard. Maetzel wound it up on the left hip, exercised once more a slight pressure on the left epaulet, and the trumpeter played in succession the French cavalry calls, a French cavalry march, a march by Dussek, and one of Pleyel's allegros, the orchestra again accompanying. The automaton's musical performance was said to be fuller and richer than could have been got from human lips.

Then there have been various writing automata invented. Knauss exhibited at Vienna an automaton which wrote; and the Drozes, father and son, constructed several mechanical figures that both wrote, and played musical instruments.

Several sets of mechanical puppets, or self-moving *marionettes*, have been introduced to the public at different times. A pantomime in five acts was performed by such a troupe in Paris in 1729; and Bienfait, in 1746, got up a representation of *The Bombardment of the City of Antwerp* by automata. Bienfait's company went under the name of the *Comédiens practiciens.* Another of their pieces was *The Grand Assault of Bergen-op-Zoom.*

Although not a complete automaton, the Chess-player of Van Kempelin, introduced to the public in the eighteenth century, merits a passing notice. By this contrivance the figure of a chess-player, sitting at a table in front of a chess-board, was made to play, apparently automatically, with any member of the audience, and proved a match for the most accomplished players. The figure and machinery were always submitted to the inspection of visitors, and moved from place to place on the platform, under the pretence of making collusion impossible, and then the game began. Of course there was a person concealed —a first-rate player—to and by whom signs were conveyed, and the game proceeded to the astonishment of the audience, much as the mechanical card-players of the present time carry on their skilful deception. The principle of the automaton is only partially applied in these instances.

Although inventors no longer take the trouble to construct automata of such wonderful capacity as the flute-player of Vaucanson, the trumpeter of Maetzel, or the coach and horses of M. Camuz, automata-making still goes merrily on in a small way, the Swiss being especially clever in the application of mechanical figures to clocks, musical-boxes, and other artistic articles. Then in many of our large cities we have automatic clock-bell strikers and automatic pumping and lifting figures of all descriptions. But the mechanic in automata lays no claim to the title of inventor in these days ; he is a toy-maker pure and simple, and aims only at pleasing children, not providing diversion for grown men and women. Weak imitations of Vaucanson and Maetzel are to be found occasionally at popular exhibitions, but the true inventor now rarely steps out of his own proper sphere to indulge in such trifles as toy-making.

CHAPTER XV.

INVENTORS ON THE SEA.

The First Vessel—Nature's Suggestions—Peter Jansen's Ark—The *Syracusan* of Archimedes — King Alfred's Fleet — Anglo-Saxon Ships—Norman and Plantagenet Fleets—England's First Naval Engagement with France—Henry VIII.'s *Harry Grâce de Dieu*—Defeat of the Spanish Armada—The *Sovereign of the Seas*—England's "Wooden Walls"—Steam as a Propelling Power Thought of—Experiments in the Eighteenth Century—Fulton, Miller, Taylor, and Symington—Fulton in Paris—His Success in America—His First Trip up the Hudson—Adoption of the Steam-ship in Europe—Ocean Steamers—The Screw Propeller—"Screw" Smith—Iron Substituted for Wood in the Building of Ships — The *Great Eastern* — Vessels of War—Iron-plated Ships—Turret Ships—The *Captain*—England's Floating Fortresses.

THE first vessel to be launched upon the water was a boat constructed from the trunk of a tree, which the people of the Polished Stone epoch, by alternate burning and cutting, contrived, in a small way, to render navigable. From that primitive beginning to the development of masts and sails would be a natural and easy transition, for which Nature would supply suggestions. Was there not the nautilus, with its gossamer sails, to teach the way of floating with the wind? Were not ducks plying oars and fishes using rudders? It would have been strange indeed if, with all these examples before him, man had not "gone down to the sea in ships" at a very early stage of his existence. Shelley, in his "Rosalind and Helen," lets his fairy fancy glide away

> "with a dry leaf for a boat,
> With a small feather for a sail."

Into the antiquity of shipbuilding, however, we do not propose to go. Our business is mainly with inventors who have gone to sea in modern times for purposes of pleasure, commerce, or war; else we might picture the varying styles and shapes of ships, from the tree-trunk and inflated-skin period slowly down through the centuries — here describing the papyrus boat, "daubed both with slime and with pitch," in which Moses was exposed "by the river's brink"; here examining the ark of Noah in all its details and proportions; here touching upon the barge-like Egyptian boats, the galleys of classic Greece and Rome, the gondolas of ancient Venice, and the sturdy galleons of the Middle Ages—until we arrive, after a long and tedious voyage, in the labyrinthine maze of a modern dock, with its forests of masts and sails and funnels. No; we have in these times to deal with a world's navy which comprises some fifty thousand sailing vessels and about eight thousand steam-ships, nearly one-half of which fleet belongs to Great Britain. In the improvement and expansion of this navy the inventor has found, and still finds, the fullest scope for the exercise of his skill.

At the beginning of the seventeenth century the Dutch merchant, Peter Jansen, had a ship built of the same proportions as the ark of the Deluge. Jansen's ark was well adapted for freightage but unsuitable for quick voyages. Centuries before then Archimedes had built a vessel, which carried on each side six hundred young men fully armed, and an equal number on the masts and attending the engines for throwing stones. This monster ship, which was called the *Syracusan*, had three "galleries or corridors"—three decks, in fact—the middle one containing thirty rooms, in each of which were four beds; and the vessel was everywhere decorated with statues, paintings, and precious stones. In this later time we have our *Great Eastern*, the leviathan of leviathans, with its grand, unmanageable massiveness, which, after a career of greater or less ill-fortune, was utilised as an enormous floating theatre and palace of amusement. It is not, however, with such freaks of nautical fancy or such evidences of o'er-leaping shipbuilding ambition as these that we are now concerned, but with the romance of the sea that had its beginning with King Alfred, that touched its chief poetic glory with the adventurous voyages of the early maritime discoverers, and that finds its most successful development in the ships wherein iron and steam combine to bring the winds and waves into subjection to man.

Britannia ruled the waves in the days of Alfred, who instituted the custom of demanding upon the seas a first salute for the English flag from the ships of other nations. Alfred established a fleet of sixty-oared galleys, with which he more than once vanquished invading fleets, and before he died he doubled the number of the vessels. Under Edgar, the twelfth of our Anglo-Saxon monarchs, the 120 ships of Alfred had increased to 350. Athelstan took a deep interest in maritime pursuits. He decreed that the merchant who had made three voyages on his own account should be raised to the dignity of Thane; and his sailors used to round the African Cape, the alleged discovery of which, centuries later, gave renown to Bartolomeo Diaz. During the reign of Ethelred an attacking fleet was sent across the northern sea to chastise the saucy Danes, with the Right Reverend Father in God, Escwy, Bishop of Dorsetshire, as acting

Admiral of the Fleet; and then and thereafter many conflicts took place at sea between the Norse and English ships, and not always to the advantage of the latter either. Harold's ships routed the war barks of Olaf, though they were unequal to the task of driving back the fleet which landed William the Conqueror at Hastings. William, as soon as he had firmly established himself in power, took steps to prevent any one else from effecting a landing. He founded the Cinque Ports of Sandwich, Dover, Hythe, Romney, and Hastings, and set up a system of coast defence, which, for the time and the people, was sufficient. Henry II. equipped a fleet for the conquest and annexation of Ireland; and Richard I., in his Christian zeal, fitted out another fleet for the Holy Land, with which, amongst other gallant feats, capture was made of Sultan Saladin's famous man-of-war, the *Dromunda*, one of the giants of the seas of those days. When Cœur-de-Lion joined the fleet at Messina, Richard of Devizes tells us, he found there one hundred sail and fourteen busses, which were large ships of burthen, with a bluff bow and bulging sides, chiefly used for purposes of transport. "The principal ships," writes Sir Nicholas Harris Nicolas, "had three spare rudders, thirteen anchors, thirty oars, two sails, three sets of all kinds of ropes, and duplicates of everything else which a vessel could require, except the mast and boat. Each vessel had a skilful commander and a crew of fourteen sailors, and carried forty war-horses with their armour, the same number of foot soldiers, and provisions and stores of all kinds for twelve months." Like the war-ships of the Romans, Richard's galleys were propelled by oars, though they had only two banks of rowers, whereas the Romans had sometimes as many as six, some oars striking the waves with a long, and others with a short stroke.

King John was the first English sovereign to send out a fleet against France, which fleet was commanded by William Longspée, the son of Fair Rosamond, and succeeded in vanquishing the enemy off Bruges, sending back to England prizes to the amount of 300 sail. This was in 1213. Other naval engagements between the two Powers took place in the reigns of Henry III. and Edward I.; and during the stormy period of Edward III. the British fleet found abundant employment, achieving a victory over the French and Flemings in 1340 with 260 ships. As yet, however, no regular navy had been established, the vessels of war being mostly hired. It was not until 1512, under Henry VIII., that a Navy Office was founded, with Commissioners to superintend the building of ships for the Crown and order maritime matters generally. Many encounters now occurred at sea between England and her enemies, the British ships contriving to keep all other fleets in check, and winning many gallant fights. Then came the desire, which has never since died out, to build ships of surpassing magnitude and power. Out of this ambition sprang that famous ship *Harry Grâce de Dieu*, a four-masted vessel of a thousand tons portage, which made a remarkable sensation in those days. It was popularly believed that this monster of the deep "swept a dozen flocks of sheep off the Isle of Man with her bobstay," but, be this as it may, she gave an impetus to shipbuilding in this country which greatly aided commercial enterprise. Elizabeth largely increased the number of the royal ships, and some of her more prominent subjects built vessels also, which in times of peace were employed in the conveyance of merchandise, and in times of war were placed at the service of the Queen.

Then came England's great opportunity, of which she availed herself to the full. The religious persecutions of Spain and France banished to this country a large number of foreign artisans, by whom new industries of importance were built up, giving rise to a wealth of commercial speculation which made ships of transport a greater necessity than ever. With these fresh and invigorating impulses at work, the national spirit awoke into brilliant activity, and England entered into naval competition with mighty Spain, then the ruler of the waters, both by virtue of its American discoveries and its strength of fleet. The pinks and caravels of light tonnage with which Vasco da Gama rounded the Cape of Storms and bombarded Calicut, and the cruisers that hoisted the red and yellow flag of Castile on the Spice Islands and the lonely isles of the Antarctic, were excelled by the English shipbuilders, and there arose a band of British navigators able and willing to steer British ships in search of treasure over all the seas of the world. The occasion generally finds the man. Frobisher sailed away to the Polar Seas on a quest upon which so many brave men have since risked and lost their lives; Drake went forth to those southern lands of romance where Spain was already plundering and enriching herself by the exercise of a not unpicturesque tyranny; and many other adventurous and chivalrous spirits, each in some distinctive fashion, advanced the glory of English seamanship in the days of Queen Elizabeth. No wonder that Philip became jealous of this growing Power, and, angered as well by his religious animosity, determined upon lowering the pride of these island upstarts. His great Armada, the most powerful naval fleet that had ever been equipped, consisting of 149 vessels, carrying 8,000 sailors and 20,000 soldiers, was despatched from Spain and loomed in sight of the British coast on the 20th of July, 1588. The total defeat of this immense fleet by a handful of British ships under the command of Drake and Hawkins had the effect of at once putting England in complete command of the seas. The Armada which had cost Philip five years and untold treasure to prepare was destroyed at a single stroke.

All through the reign of Elizabeth, British seamanship prospered. A merchant navy grew up, gradually yet steadily, and the work of colonisation was entered upon with much earnestness, largely increasing the demand for ships.

Shipbuilding now became an important industry, and began to engage the attention of men of inventive ability. Under James I., the Petts succeeded in building ships of a much improved pattern, the finest achievement in this direction being the *Sovereign of the Seas*, which, for a period of nearly sixty years, took a leading part in England's naval engagements. The Thames began to be lined with dockyards, the operations in which were, in Charles II.'s time, of sufficient attraction to inspire Dryden with poetic images. He says :—

> "Some the galled ropes with dauby marline bind,
> Or sere-cloth masts with strong tarpaulin coats;
> To try new shrouds one mounts into the wind,
> And one below their ease or stiffness notes."

Still, ships remained much the same from century to century; they were increased in size and strength, and perhaps in grace, but they continued to be built of timber, and were steered and impelled in the same fashion—by sails and oars—as they had been from ancient times. England had good reason to be proud of her "wooden walls," for the brave hearts that went with them to victory; and of her merchant fleet, for the commercial greatness it brought her: but the inventor was yet to come with his revolutionary ideas concerning means of propulsion and construction—ideas which were destined to give new life and power to the art of navigation.

Steam had been dreamt of as a propelling power for ships by men of science long before it came to be practically applied. That ingenious nobleman, the Marquis of Worcester, had hinted at it in 1661; Denis Papin, while at Marburg, had actually fitted a small steam-engine in a boat, and almost solved the problem, in 1707; Jonathan Hulls had experimented with a paddle-wheel and a Newcomen engine, in 1736; and three clever Scotsmen—Miller, Taylor, and Symington—in 1788, had made steamboats, in which the principle of the present steamboats was clearly demonstrated.

Fulton, a young American artist, who had come to England the previous year with an introduction to his countryman West, was amongst the men who saw something of the experiments of Symington in Scotland. He believed in them so much that he soon afterwards relinquished art for invention, and began to construct a steamboat of his own. In London, Fulton made the acquaintance of Dr. Cartwright, the inventor of the power-loom, and with him often discussed the question of the practicability of steam navigation. Cartwright himself constructed the model of a boat which, being wound up like a clock, "moved on the water, so as to prove the experiment in a manner satisfactory to the inventor." This idea seems to have been fructifying in Fulton's mind for several years before anything practical came of it. In 1797 he removed to Paris, and for the next seven years lived there, in the house of a friend.

The progress of his inventions is indicated in a letter to Cartwright in the year following. "The steam-engine, I hope," he writes, "may be made useful in cutting canals and moving boats, so that it will be directly in my line of business. By-the-bye, I have just proved an experiment on moving boats, with a fly of four parts, similar to that of a smoke-jack. . . . I find this apply the power to great advantage, and it is extremely simple." He did not get much further with his idea until 1802, when Mr. Livingstone came to Paris as United States Minister, and urged upon the inventor the advisability of continuing the enterprise with greater energy. Fulton now constructed a number of ingenious models with which he made experiments on a small rivulet at Plombières, a boat sixty feet in length and eight feet wide being built for the purpose of the trials. This boat did not carry him very far on the road to success, for one morning in the spring of 1803, when he was on the point of leaving home for a special experiment, a messenger arrived with the intelligence that the craft had broken to pieces and gone to the bottom. The machinery had been too heavy for the boat. The vessel was then rebuilt, and in the August following a further trial was made on the Seine, in the presence of a multitude of Parisians; and although the speed attained did not answer expectation, the experiment was regarded as a successful demonstration of the practicability of steam navigation. In 1804 we find him in England negotiating with the British Government for the sale of an invention of submarine warfare which they declined to buy, but rendered inoperative by purchasing his neutrality. At the end of 1806 he returned to America, after ordering from Boulton and Watt a steam-engine "suited to the purpose of propelling a boat by means of a cranked axle and paddle-wheel, and directing it to be sent out to him in America." This engine was in 1807 transferred to a boat specially built for its reception—the *Clermont;* and this, the first complete steamer, made a trip up the Hudson, achieving a speed of five miles an hour.

Fulton did not attain his object without the trials and heart-burnings, the scorn and derision common to inventors. He made known to Judge Story, the eminent American lawyer, the bitterness of his experience. "When I was building my first steamboat at New York," he said, "the project was viewed by the public either with indifference or contempt, as a visionary scheme. My friends, indeed, were civil, but they were shy. They listened with patience to my explanations, but with a settled cast of incredulity on their countenances. I felt the full force of the lamentation of the poet—

> 'Truths would you teach, to save a sinking land;
> All shun, none aid you, and few understand.'

As I had occasion to pass daily to and from the building yard, while my boat was in progress, I have often loitered unknown near the idle groups of strangers, gathering in little circles, and heard various inquiries as to the object of the new vehicle. The language was unfortunately that of scorn, or sneer, or ridicule. The loud laugh often rose at my expense; the dry jest, the wise calculation of losses and expenditures; the dull but endless repetition of the Fulton Folly. Never did a single encouraging remark, a bright hope, or a warm wish, cross my path. Silence itself was but politeness, veiling its doubts, or hiding its reproaches. At length the day arrived when the experiment was to be put into operation. To me it was a most trying and interesting occasion. I invited many friends to go on board to witness the first successful trip. Many of them did me the favour to attend, as a matter of personal respect; but it was manifest that they did it with reluctance, fearing to be the partners of my mortification, and not of my triumph. I was well aware that in my case there were many reasons to doubt of my own success. The machinery was new and ill-made; many parts of it were constructed by mechanics unaccustomed to such work; and unexpected difficulties might reasonably be presumed to present themselves from other causes. The moment arrived in which the word was to be given for the vessel to move. My friends were in groups on the deck. There was anxiety mixed with fear amongst them. They were silent, and sad, and weary. I read in their looks nothing but disaster, and almost repented of my efforts. The signal was given, and the boat moved on a short distance, and then stopped and became immovable. To the silence of the preceding moment now succeeded murmurs of discontent, and agitations, and whispers, and shrugs. I could hear distinctly repeated: 'I told you it would be so; it is a foolish scheme; I wish we were well out of it.' I elevated myself on a platform, and addressed the assembly. I stated I knew not what was the matter, but if they would be quiet, and indulge me for half an hour, I would either go on, or abandon the voyage for that time. This short respite was conceded without objection. I went below, examined the machinery, and discovered that the cause was a slight mal-adjustment of some of the works. In a short period it was obviated. The boat was again put in motion. She continued to move on. All were still incredulous. None seemed willing to trust their own senses. We left the fair city of New York; we passed through the romantic and ever-varying scenery of the highlands; we descried the clustering houses of Albany; we reached its shores; and then—even then, when all seemed achieved—I was the victim of disappointment. Imagination superseded the influence of fact. It was then doubted if it could be done again, or, if done, it was doubted if it could be made of any great value."

It was not long before Fulton's fame and fortune were established; and after a few years steamships were in operation in all parts of the civilised world.

Europe was rather slow to take full advantage of the new invention, and it was not everybody that looked upon it with favour. Victor Hugo has described it as "a thing which smoked and clacked on the Seine, making the noise of a swimming dog," which "went and came from the Tuileries to the Pont Louis Quinze—a machine good for very little—a nightmare dream from Utopia—a steamboat."

In 1815 the first Thames steamer plied between London and Richmond; in the same year a steamboat made the voyage from the Clyde to the Thames; and in 1819 the *Savannah* steamship crossed from America to England, leaving the port of Savannah on the 25th of May, and landing in Liverpool on the 20th of June. Ocean steam voyages did not, for all that, become common for some time afterwards. In 1825 the first steamship voyage was made from England to India; in 1833 a second steamer crossed the Atlantic, the *Royal William*, from Quebec to Gravesend; and in 1838 regular steamship traffic between this country and the United States was successfully established.

The steamship was by no means a complete invention when it left the hands of Fulton. Engines and paddles of greater power were from time to time introduced, and an improved speed was realised; still, with the example of the railway locomotive now always at hand, with its speed of forty, fifty, and even sixty miles an hour, the rate at which the steamship travelled did certainly seem slow. It was thought that some better method of ploughing the waters than by the use of paddles might be devised. Fulton himself does not appear to have been altogether satisfied with this mode of propulsion, for he tried many other methods, including the screw, which was destined to supersede all others for ocean-going traffic.

The history of the screw-propeller is curious and interesting. Here again we get a crossing of ideas by men working independently of each other. James Watt had the notion of a "spiral oar" for the propulsion of canal boats so far back as 1770; Joseph

Bramah was another inventor who, in 1785, projected a scheme with a similar object; Joseph Ressel, an Austrian, took a patent out for a screw in 1794; and Richard Trevethick patented a screw-propeller in 1815. Captain Ericsson, of the firm of Braithwaites and Ericsson, constructed a steamboat on the screw principle in 1837, which made a speed of ten miles an hour on the Thames, and towed a large American steamer up the river at five miles an hour. The attention of the Government was drawn to the invention, but they declined to have anything to do with it; so the disappointed inventor went over to America, where his screw was adopted, and he himself succeeded in establishing a line of steamers, and was commissioned to build war steamers for the United States navy. Among Ericsson's latest inventions, by the way, is a new torpedo-boat, which, according to the inventor, will be the most terrible engine of warfare ever invented, being capable of overtaking the swiftest vessel afloat, and carrying a torpedo which will be able to shatter and sink the strongest ship.

The inventor, however, to whom the chief credit of the introduction of the screw-propeller into this country is due is Francis Pettit Smith, who, even before Ericsson's experiments in the same direction, had established the power of this new mode of propulsion. He constructed several models of screws from time to time, and in 1836 took out his first patent for "propelling steam vessels by means of a screw revolving beneath the water at the stern." This invention he exhibited at the Adelaide Gallery, and it attracted the notice of a couple of capitalists, who found the money necessary to push forward his experiments. A boat was built according to Smith's plans, and from the autumn of 1836 to the autumn of 1837 regularly plied on the Thames. During her trips upon the river, "a happy accident occurred," writes Dr. Smiles, "which first suggested the advantage of reducing the length of the screw. The propeller having struck upon some obstacle in the water, about one-half of the length of the screw was broken off, and it was found that the vessel immediately shot ahead and attained a much greater speed than before. In consequence of this discovery, a new screw of a single turn was fitted to her, after which she was found to work much better."

In September, 1837, the little vessel—it was of ten tons burthen and six-horse power—was taken out to sea, and, to the delight of the inventor, attained a speed of over seven miles an hour in spite of a heavy sea. Still he could not prevail upon the shipbuilders to take the invention up, nor were the Government inclined to do much for him, unless he could, by an experiment on a much larger scale, prove beyond doubt that the screw-propeller was an improvement on the paddle. Smith had faith in his ability to do this, and, fortunately, he found men of means ready to back him up by *their* faith. On this the "Ship-propeller Company" was established, with the result that the *Archimedes* was built and launched, and proved more than equal to promise. The *Great Britain* was being constructed about this time by I. K. Brunel, at Bristol, and so favourably was the engineer impressed by the new propeller, that he altered the construction of his vessel from the paddle to the screw, and when, in 1845, she made her first voyage to New York in fourteen days, it was acknowledged by the engineering world that a new era in steam navigation had been entered upon. From that time the screw-propeller made its way more and more into favour, and even the Lords of the Admiralty by degrees came to adopt the principle for their ships of war.

"Screw" Smith, as he was called, did not make his fortune by his invention, unluckily, nor did the Ship-propeller Company turn out an altogether successful concern, for Smith's patent-right expired before screw ships came generally into use. A pension of £200 a year was granted him from the Civil List; a testimonial subscription of over £2,000 was got up for him; he received the appointment of Curator of the Patent Museum at South Kensington; and in 1871 was knighted. He died in 1874. As for the Ship-propeller Company, it sustained a loss of £50,000, and ceased to be.

He was a bold man who first proposed to substitute iron for wood for the building of ships; for, to the popular mind, iron presents itself as a substance that must inevitably sink, while wood is unsinkable. But the idea of using iron for shipbuilding is not quite so new as is generally imagined. One John Wilkinson, of Bradley Forge, in Staffordshire, built an iron vessel in 1787, and set it afloat on the Severn, where it continued to ply successfully for some years. Other iron ships were built at intervals, and in 1821 an iron steamship was launched from the Horsley's Company's works, in Staffordshire. Sir W. Fairbairn strongly advocated the use of this material for ships, and other engineers supported his views. Brunel favoured iron, and built the *Great Britain* of that metal. Indeed, from about 1850, the use of iron became general for ships of all kinds. The largest ship that was ever launched — the *Great Eastern*—was built of iron, and, unfortunate as its career has been, the probability is that if it had been constructed of wood its fate would have been still more disastrous. Its chief value to the world seems to have been in proving to the satisfaction (or dissatisfaction) of ship engineers that there is a limit of size, beyond which it is not commercially safe to go. The half a million sterling invested in the huge ship can never be recouped, but as a monument of the shipbuilding enterprise of the nineteenth century, this floating town, with its 692 feet of length, its 83 feet of width, its 60 feet of depth, and its tonnage of 24,000 tons, must long continue to excite the admiration of a world that delights in wonders of magnitude.

But the *Great Eastern* is not the only mistake of modern shipbuilding. Bessemer, successful as he has been as an inventor on what may be regarded as his own ground, did not, in that ingeniously contrived Channel steamer of his which bore his name, quite perform all that he meant to perform. The idea was excellent—a saloon suspended on pivots, which would keep its horizontal position no matter how the external shell of the ship might be tossed to and fro, and up and down—but somehow, in practice, it failed, and Channel passengers have still to battle with seasickness as they had before. The *Castalia*, another attempt in the same direction, designed by Captain Dicey, disappointed expectation. It consisted of two hulls girded or bridged together, the bridge portion being raised out of the water, giving the effect of two vessels running side by side.

Turning now for a moment to ships of war, we get away from the field of romance. There was poetry in the old "three-deckers" and in the grand line-of-battle ships of Nelson's day—the "wooden walls of England"; there was dash and jollity in the life of the seamen; but the inventors have, in these days, turned the man-of-war into a huge machine of destruction, and personal bravery hardly comes into the reckoning. On our vessels of war we now spend millions where before we spent only thousands. As fast as one set of inventors builds ships of seeming impregnability, another set of inventors brings forward guns of greater power capable of demolishing them; and so the struggle is kept up year after year with increasing force, until naval engagements have become mere questions of machinery.

Floating batteries, plated with iron, were first employed in the Crimean War. Then the French introduced their armour-plated ship *La Gloire;* and England followed with the *Warrior*, which surpassed all previous ships of war in point of strength. The *Warrior* had an iron frame, with armour-plates four and a half inches thick, backed by eighteen inches of solid teak-wood, and provided with an inner sheath of iron. It was capable of resisting the impact of the heaviest projectile that could then be thrown by naval guns—a 68lb. shot—and all might have been well if the projectile inventors had not gone on inventing. It is always necessary to be designing ships of greater power of resistance than their predecessors, and so since the days when the *Warrior* held the first position in the fleet a gradually increasing strength has been displayed. The ironclads of later construction leave the *Warrior* far behind in the race for supremacy, and the complaint is still heard that the English do not keep pace with the requirements of the time.

Among the ships of war in which the inventor has made special efforts to obtain novelty of construction, may be mentioned the ill-fated *Captain*, built under the direction of Captain Coles, about 1861. In this vessel and the *Monarch* a new system of mounting heavy guns was introduced, by which ordnance of great calibre was carried on revolving turrets erected on the deck of the ship. It was also fitted with twin screws. A hurricane deck was built over the turrets, and the ship was fully rigged and carried a large spread of canvas. Each turret was mounted with two 25-ton Armstrong guns, capable of receiving a charge of 70 lbs. of gunpowder and of throwing a 600-lb. shot. The *Captain* was sent on a cruise in the autumn of 1870, and about midnight, on the 6th of September, she suddenly foundered, when, out of a crew of five hundred persons, only nineteen were saved. Captain Coles, the inventor, perished with the rest.

The turret system was not discarded after this disaster, but altered in its application somewhat, the *Glatton*, designed by Sir E. J. Reed, and launched in 1871, being a successful example of this class of vessel, forming an almost impregnable floating fortress, with destruction-dealing powers of vast extent. The turret system has been more or less followed in most of the men-of-war which have been built of late years. England's most formidable war vessels now afloat are the *Inflexible*, the *Ajax*, the *Agamemnon*, the *Devastation*, the *Thunderer*, the *Dreadnought*, the *Colossus*, and the *Edinburgh*. The *Inflexible* has been described as "simply an armoured citadel, with unprotected ends lying beneath the surface of the water to keep her afloat." She carries four guns, each capable of firing a shot of 1,700 lbs., and all four can be fired at once, and in the same direction. She is 320 feet in length, and 75 feet wide. The *Ajax* and *Agamemnon* are built on the same plan, but are somewhat smaller in size. The *Devastation* carries two turrets, plated with 14-inch armour, and has four 35-ton guns. The turrets are enclosed in a central armed citadel, the deck in front of it being given up wholly to the waves in rough weather, but a narrow deckhouse, running between the two turrets, is opened out at the top so as to form a spacious hurricane deck 24 feet above the water. She can carry 1,600 tons of coal, and has a speed of nearly fourteen knots. The *Thunderer* is similar to the *Devastation* in every respect, except that her guns are of 38 tons, and are worked by hydraulic power. The *Dreadnought* is a larger ship, although her gun equipment is the same. Her sides are plated with 14-inch armour. The *Colossus* and the *Edinburgh* are each 325 feet long, and their displacement is 9,150 tons. Their armour is 18 inches thick and steel-faced, and each carries four 43-ton guns in its turrets, as well as four six-inch breech-loaders. The speed of the *Colossus* is 16½ knots, and that of the *Edinburgh* 16 knots.

Such are the "iron walls" which have now taken the place of the old "wooden walls." They in their turn will be superseded, for the battles of the inventors continue whether their inventions ever get into battle or not. There are already ships being built of steel. But, perhaps, the department of shipbuilding which is the most active in these days is that of torpedo construction. These operations, however, are carried on with great secrecy, the torpedo inventor being a man of mystery All the navies of the world are being supplied with these diabolical engines of destruction, the power of which is being constantly increased. In 1886 the various torpedo fleets showed the following figures:—Great Britain, 120 torpedo craft; Russia, 115; Germany, 85; France, 79; Austria, 150; Italy, 40; Spain, 25; Greece, 48; the Netherlands, 29.

Still, despite this terrible parade of pride and strength, the true-born Englishman looks back with longing to the former time, when Dibdin sang his sea songs, when the press-gang was a British institution, and when the privateer and the pirate played prominent parts in the conflicts of the seas.

CHAPTER XVI.

AMONGST THE WIRES.

The Wire-workers of Early Times — The Touch of Electricity — Early Experimenters — Electro-magnetism Discovered — Wheatstone and Cooke—The First Electric Telegraph Patent—Morse and Dr. Jackson on Board the *Sully*—A Welcome Visitor—Morse and Jackson in Litigation—Europe's Recognition of Morse—The First Submarine Cable—An Atlantic Cable Projected—Repeated Failures—Cyrus W. Field—A Seven Years' Interval—The *Great Eastern* is Entrusted with a New Cable — Another Failure—Ultimate Success — Wheatstone's Wire Sound-transmitter — Captain Taylor's Telephone of 1844—Later Experimenters in Germany, America, and England—Professor Bell's Telephone—Number of Telephones in Operation.

IN the "fairy tales of science" none is more wonderful than that of the wires. From the first historic mention of these metallic threads down to the latest speculation concerning some still latent powers of theirs, the story is truly one of enchantment and romance.

In the Scriptures we read that in the preparation of Aaron's sacerdotal garments, the makers of the ephod "did beat the gold into thin plates, and cut it into wires, to work it in the blue, and in the purple, and in the scarlet, and in the fine linen, with cunning work;" and from the fantastic realm of mythological fable there comes to us the legend of the network of gossamer wire, delicate as a spider's web, which Vulcan forged for the entrapping of Mars and Venus. Wire, in the form of the needle, has threaded its way through all human history, and, from the cloth of King Attalus to the tapestries of our Norman queens, from the winding-sheet of St. Cuthbert to the lace nightcap of Mrs. Nickleby, has always had its accompaniment of song and story, sad or gay—it may be the song of Deborah, or it may be the Song of the Shirt.

As wire, pure and simple, elongated and ductile, it has had its multiform uses through the ages, like other common things, and the wire-drawers have been accounted a sturdy race of artisans; but the true importance of this well-known substance was never asserted until, by a happy thought, science touched it with the electric current and taught it to outdo Puck, and put a girdle round the earth in even less time than was allowed to that immortal mischief-maker. It would need volumes to tell how this marvel was wrought by the brain of man, for the story is closely interwoven not only with the history of individuals but with the history of communities, and is yet far from being at an end, fresh wonders issuing from the metallic cords, like sparks from the anvil, with every new effort of the inventor's genius.

Long before Galvani had received that valuable lesson in science from the frog, and longer still before Volta had established the correct explanation of the phenomena produced by the contact of dissimilar metals, the Jesuit Strada, in the seventeenth century, had speculated upon the possibility of communication between persons at a distance from each other by means of sympathetic needles—a pretty conceit which an English poet afterwards took up and hung many pleasing fancies upon. But it was not until the early part of the present century that the idea of transmitting thought by means of the electric current began to take shape in the minds of scientific men. Experiments in this direction were made with voltaic electricity in 1808, after the discovery of the power of the pile to decompose water; and Sommering proposed an arrangement of electrodes, formed by gold pins passed through the bottom of a glass containing acidulated water, to which a method of signals was attached, and this came very near establishing the principle of the electric telegraph, but never made its way into practical use. Some dozen years later, Mr. Ronalds, of Hammersmith, invented a method of pointing out letters on a dial at a distance by means of frictional electricity, and this was another step in advance, though it failed to be adopted. This inventor endeavoured to obtain the favourable notice of the Admiralty for his apparatus, but the answer was that "telegraphs of any kind were wholly unnecessary."

It is interesting to watch how gradually the electric telegraph was arrived at by the working towards the same end of many able minds. Oersted discovered the principle of electro-magnetism in 1819, and a fresh line of experiments was immediately suggested. Ampère advocated the obtaining of an electric telegraph with needles surrounded by wires, but did not get beyond a separate needle and wire for each signal to be transmitted. This was desperately near the solution of the problem, but it did not solve it quite. Schweigger had suggested for Sommering's telegraph the production of signals by different combinations of two movements, making two needles and two wires only necessary, and if Ampère had thought of this the electric telegraph might have been an accomplished fact twenty years before it was. Baron Schilling got a step further in 1835, and Gauss, Weber, Steinheil, and others, busied themselves with telegraphic experiments.

Meanwhile, Professor Wheatstone, in conjunction with Mr. W. Fothergill Cooke, was making experiments in England, with a view to establishing a practical system of telegraphy, and in 1837 these two gentlemen took out a patent for an electric telegraph apparatus, in which five magnetic needles were brought into use as pointers to the various letters of the alphabet indicated on a dial. The wires had now received their magic message. The system was adopted on the London and Blackwall Railway, and it was in England that the first practical illustration of the principle of the electric telegraph was seen on any considerable scale. Wheatstone and Cooke reduced the number of their needles to two shortly afterwards, and effected other improvements, ultimately patenting a single-needle instrument in 1845.

Professor Morse was actively engaged in the United States for many years before this, endeavouring to invent a telegraphic apparatus on a somewhat different plan from that of Wheatstone and Cooke. His notion was to provide at the sending end a voltaic battery, and at the receiving end an electro-magnet, which, when the current passed, attracted an "armature" placed at the pole, whereby dots or lines were marked with a steel point upon a moving slip of paper, enabling the operator to read off the message as it arrived.

There was a touch of romance connected with Morse's taking up of the electric telegraph idea, but more than a touch of reality fell to him before the idea was worked out. It is related that in October, 1832, he was one of a number of passengers by the steamship *Sully*, bound from France to the United States. He had been studying art in Paris, and had something of a reputation as a painter. During his voyage across the Atlantic he made the acquaintance of a Dr. Jackson, and the two got talking on scientific subjects. Electricity was the topic one day, and Morse suggested to his fellow-passenger the possibility of employing this force in exchanging signals at a distance. Dr. Jackson sketched a galvanic battery and an electro-magnet, which was amongst his baggage but inaccessible, for Mr. Morse, and the artist seems to have made good use of these, for they evidently sufficed to turn his thoughts in a more practical direction than they had previously taken. As events afterwards turned out, Mr. Morse had good reason to remember that voyage in the *Sully*, and particularly his friendly interchanges of thought with Dr. Jackson.

When Morse reached America he resolved to abandon his profession as an artist and devote himself entirely to the subject of telegraphy; and this he did with so much purpose that by 1836 he had perfected his first apparatus. But he had to submit to much humiliation and disappointment before he could obtain the sanction of Congress to his scheme. For a long time he had been urging the attention of the Government to the importance of his project without meeting with much acceptance for it. His means were exhausted, and it was the evening of the closing day of Congress. He was in despair, for there was such an amount of business before the House that he could scarcely hope that they would give any consideration to his scheme before breaking up for the recess. He returned to his lodgings despondent. While at breakfast the next morning a visitor was announced. It was the daughter of the Commissioner of Patents, who had heard from her father that on the previous midnight, the moment before the adjournment of the Senate, the Telegraph Bill had passed. Knowing the anxiety of the inventor, she had hastened to report to him the good news, which gave him so much delight that, after thanking her warmly for her kind and womanly sympathy, he promised that the first message transmitted by the telegraph should be indited by her. About a year afterwards the first American telegraph was completed between Washington and Baltimore, and the daughter of the Commissioner of Patents was apprised of the fact, with a request that she would send to the inventor the words for the first message. She returned a note with these words enclosed: "What hath God wrought!" and this Professor Morse sent along the American wires as their first message.

Professor Morse's invention was found to be an improvement on any other telegraphic apparatus, and, with sundry modifications which he subsequently introduced, was brought largely into use on this side of the Atlantic as well as in America. But just as the inventor was settling down quietly to enjoy the fame and fortune which his ingenious apparatus promised to yield him, there appeared upon the scene his by this time forgotten *compagnon de voyage* of the *Sully*, Dr. Jackson, who claimed to have been the inspirer and originator of the telegraphic machine upon which Professor Morse had spent so many anxious years. Morse indignantly repudiated the claim which Dr. Jackson set up, and a bitterly contested lawsuit followed, resulting in a verdict for the Professor, who after that was permitted to enjoy the fruits of his labour without molestation. A handsome recognition of the merits of his invention came to him, moreover, from Europe later on, when the Emperor of the French suggested that a substantial testimonial should be got up for him by the States which had more particularly profited by his invention. The Governments of France, Russia, Austria, Turkey, Holland, Belgium, Sweden, and the Papal States joined in the testimonial, and a sum of £16,000 was handed over to Morse as the outcome of that movement. The Morse system is now the one in most general use in all countries, and, with the recording instrument, the transmitting key, and other improvements, forms a marvellously complete invention.

The great achievement which projectors next set themselves to accomplish was the connection of Europe and America by the electric wire. This was not so much a matter for the inventor as for the promoter. It was obvious that the electric current would pass freely enough from shore to shore if only there was a possibility of laying the wires along the bed of the ocean; but this did not seem at all likely, for it was imagined that the monsters of the deep would resent such an intrusion upon their domain, and would make short work of any submarine line of wires that the enterprise of man could devise. Both Morse and Wheatstone had made satisfactory experiments with sub-aqueous insulated wires, and it had been discovered that guttapercha was admirably fitted for the purposes of an insulating sheathing for the wires. Submarine telegraphy having thus been scientifically demonstrated to be feasible, the only question was, could a telegraph cable be safely laid in the sea?

The first experiment to test this was made by Brett and Co., who laid a cable from England to

France—from Dover to Cape Grisnez, near Calais. But within a week the jagged rocks near the French coast had cut the cable in two, and those who had prophesied failure looked upon the question of submarine telegraphy as settled for ever. But the inventors and promoters were not dismayed. They immediately set about the construction of a fresh cable, giving it additional strength and protection, and in 1851 the second Anglo-French submarine telegraph line, twenty-seven miles in length, each mile of wire weighing seven tons, was successfully laid and put into active operation. Other cable schemes were then projected, and England was put in direct telegraphic communication with Belgium, Holland, and other countries. The success of these projects encouraged the advocates of an Atlantic cable, and in 1855 the public were asked to put their faith in a scheme for establishing a telegraph line between England and America. The required capital of £350,000 was at once forthcoming, and operations were commenced.

A cable was manufactured of the weight of ten tons to the mile, and in August, 1857, the two great steamships, the *Agamemnon* and the *Niagara*, had the 1,600 miles length of cable entrusted to them to pay out. All went well until 335 miles of the cable had been laid, when it was suddenly discovered that the electrical continuity had been lost. The greatest alarm was felt; the scientific directors of the expedition were in dismay; and the order to cut the cable and wind in was just about to be given when the electricity returned, and joy was in their hearts once again. It was a nasty experience, and gave rise to ugly forebodings, but as all seemed to go on right again confidence was restored. But they had not got through the night before a still more alarming incident occurred; the brakes were being applied to prevent the cable from running out too fast, when the sea gave an angry lurch to the vessel, and the cable snapped and was lost for ever. The expedition returned, and no further attempt was made to lay a cable until the following year, when Mr. Cyrus W. Field put himself at the head of the American promoters. He comprehended all the difficulties of the enterprise, and set himself to surmount them.

A more effective paying-out apparatus was designed by Mr. Everett, and, in place of the brakes which had led to the previous disaster, Mr. Appold invented what he termed "self-releasing brakes," so constructed as to give way whenever the strain exceeded a ton and a half. The same two ships set out with the cable one fine July morning from the shores of New York, the hopes of the shareholders going with them. This time a different plan was adopted. They did not begin to pay-out the cable until they had arrived in mid-ocean, and then the *Niagara* and the *Agamemnon* took leave of each other, after splicing their respective portions of cable, one proceeding in the direction of Europe, the other steaming towards America. Twice the cable broke before the ships had been long separated, and twice the connection was renewed. This was ominous, and saddening. With all their extra precautions, they were experiencing more misfortunes than their predecessors. For the third time the ships parted company, and, when a distance of 200 miles separated them, the cable broke again. The rupture was found to have taken place within 20 feet of the *Agamemnon*, but the cause of the disaster was inexplicable, which, of course, made the prospect all the worse. The ships returned home once more, and there the matter might have ended but for the indefatigable spirit of Mr. Field. There was still a sufficient length of cable left to go across, and with this Mr. Field resolved upon making a third attempt. Accordingly, after the two ships had remained in Europe just long enough to take in coal and provisions, they returned to their former starting point in mid-ocean, and on the 29th of July said good-bye to each other once again, each carrying with it its own connecting link of cable. Those were anxious days that followed; but night succeeded morning, and morning succeeded night, and no failure of continuity occurred. They could hardly believe the evidence of their senses, for there seemed to be no more reason for their present success than there had been for their previous disasters. So all went on well, confidence increasing with every day, and on the 5th of August, seven days after the two vessels had parted company, Mr. Field telegraphed to New York from the *Niagara*, Trinity Bay, Newfoundland, that the Atlantic telegraph was completed. Now, indeed, was there cause for triumph, and Mr. Field was received by his countrymen in New York with enthusiastic demonstrations of welcome such as are generally reserved only for princes and conquerors. A day was set apart to do him special honour—a day of celebration and thanksgiving, so to speak—but on that very day—after England and America had been exchanging words of greeting and amity, affection and business, by the aid of the electric current for the space of a month—the wires suddenly ceased to speak, and the third Atlantic cable lay along the bed of the ocean, a useless, silent mass!

For a time no one had the heart to suggest a further attempt. For seven years the advocates of the gigantic enterprise remained under a cloud. But in the interval the inventor had been devising methods of meeting the difficulties which had formerly presented themselves. A new cable was made of much greater strength than the former cables; and from the works of Messrs. Glass and Elliot at Greenwich there was sent out a telegraphic medium in comparison with which the combination of wires taken out by the *Niagara* and *Agamemnon* was about as slender as a thread of cotton is compared with a hempen rope. There is not much romance about figures as a rule, but the figures of this marvellous wire-making achievement are surely an exception. Seven copper wires twisted into one strand constituted the conductor, which was covered with several layers of insulating material, and these again had an external covering of eleven stout iron wires, each of which was protected by a coating of hemp and tar. The length of the cable was 2,600 miles, the length of copper wire used was 25,000 miles, of iron wire 35,000 miles, and of hempen strands 400,000 miles, or an aggregate length of all materials sufficient to encircle the world twenty-four times. This immense cargo of cable, weighing, with the iron tanks in which it was stored, upwards of 5,800 tons, was committed to the *Great Eastern*, which, for once, had a freight worthy of its own mammoth proportions.

Away the great ship sailed, with its precious load, its electricians, its special correspondents, and its army of sailors and attendants, and the hearts of the shareholders were again lightened with hope. The monster ship steamed blithely out of the harbour of Valentia on the 23rd of July, 1865, with the pleasant summer weather all around. Nothing specially disastrous occurred until the great ship had rid itself of some 1,186 miles of cable, and was 1,062 miles distant from the shores of Ireland; then there was a loss of insulation, and the cable had to be raised and examined. While this was being done the cable broke, and, after the spot had been marked by buoys, the *Great Eastern* had to turn round and go home again with the melancholy tidings of a fourth failure, which represented 4,000 miles of useless cable at the bottom of the sea and a loss of a million and a quarter sterling.

In the following year, on the 13th of July, the *Great Eastern* sailed out with another cable, on still another improved principle. This time the efforts of the electricians were crowned with success; on the 28th of July the American end of the cable was joined to the shore, and from that time to this the two continents have remained electrically connected. The old cable, moreover, was afterwards recovered and continued, and a second telegraphic communication effected; and, profiting by the lessons of past disasters, fresh ocean telegraphs have since been laid, until all the countries of the world are in a position to hold almost instant discourse with each other.

Turn we now to some other victories gained by the miraculous agency of wire. For many years back, scientific men have been amusing themselves with extracting sweet sounds from metallic substances arranged without any particular design of musical effect. Sir Charles Wheatstone and others have experimented in many ways with sound-conducting mediums; and while engaged in perfecting his telegraphic invention, Sir Charles was often startled by strange noises emitted by the wires. He was not likely to let anything of this kind pass without an attempt to bring it into subjection in some way.

One of his experiments in this connection was exhibited to the Royal Society in 1840. Mr. William Chappell made mention of it in a letter to the *Athenæum.* He wrote:—"Having seen a huge coil of wire in the well of the staircase, on entering Somerset House that evening, I went up to the library and tea-room of the Royal Society to learn what had been going on. Wheatstone pointed out to me a clock-face in the room. It was perfectly transparent, and had hands; but every one could see that there were no works within it, yet the hands moved and the clock face ticked most audibly. He took me out on the staircase to hear the perfect simultaneity, and the equal force of the tick with that of the clock in the hall below. It was the sound of that clock which had been conveyed through a coil of wire of some miles in length to the clock-face in the library on high. The sound above and the sound below were in perfect unison, and of absolute equality in force as well as of pitch. As this was the first electric clock, so Wheatstone was the first to employ the electric wire for the transmission of sounds, as well as to transmit them by rods, without the use of electricity." This was undoubtedly the germ of what we now call the telephone.

In 1844, however, Captain John Taylor invented an instrument to which he gave the name of the telephone ; but this was on a different principle. Captain Taylor's invention was a powerul wind-instrument for conveying signals at sea during foggy weather, the sounds being produced by means of compressed air forced through trumpets, audible at a distance of six miles. This, and other experiments, all tended to show that the subject of sound transmission was receiving a large share of attention.

We get a little further on the way to a great discovery when, in 1860, we come upon Professor Reis's experiments at Friedrichsdorf. Out of an ingenious combination of a coil of wire, a knitting-needle, the skin of a German sausage, the bung of a beer barrel, and a strip of platinum, Reis constructed an instrument which conducted the voice by the vibration of the membrane, and sent a series of clicks along an electric wire to an electro-magnetic receiver at the other end. The idea was taken up in America ; and Mr. Edison and Mr. Elisha Gray both helped the discovery another step nearer to the point of practicability. Paul Lacour, of Copenhagen, also experimented with success with telephonic apparatus. But it was reserved for Mr. Alexander Graham Bell to crystallise all these wandering speculations into one perfect instrument of great simplicity. An apparatus, the result of many years' experiments, was exhibited by Mr. Bell at the Philadelphia Exhibition of 1876, which was alluded to by Sir William Thomson as "perhaps the greatest marvel hitherto achieved by the electric telegraph." It was described as having been obtained "by appliances of quite a homespun and rudimentary character ;" and it was added, "with somewhat more advanced plans and more powerful apparatus, we may confidently expect that Mr. Bell will give us the means of making voice and spoken words audible through the electric wire to an ear hundreds of miles distant."

The telephone took the world by surprise. It was almost past belief that a person at one end of a wire could hold converse with an individual at the other end, though miles away, and hear every intonation of the voice with distinctness! Was it possible that any one, while sitting at home in his drawing-room, might listen to a concert, a political speech, or a sermon in a distant town, by simply putting his ear to the single wire of the telephone! Man's sphere was enlarged by this latest emanation from wireland, and he did not neglect to take advantage of it. To-day England has 15,100 telephones in operation; Germany, 14,700; America, 350,000; and Canada, 18,000. In January, 1886, there were 137,223 miles of telephone wire in the United States alone. In France the telephone system is administered by the Post Office, and the Parisian is able to enjoy a ten minutes' conversation along the wires when he pleases for 25 centimes. The sixpenny telegram can hardly be considered equal to this as a national privilege.

CHAPTER XVII.

INVENTIONS DISCOVERED BY ACCIDENT.

Pliny's Story of the Discovery of Glass—Accidental Discoveries by Potters—The Telescope—A Series of Accidental Revelations of the Power of Steam—The Lazy Cock-boy—Schwanhard and the Art of Etching on Glass— Berthollet, Courtois, Senefelder, Argand, Montgolfier, and Priestley—Prince Rupert and the Rusty Gun—Signora Galvani and her Dish of Frogs—The Bayonet—A Dream that Came True—"Water-tabbies"—Murdoch's Discovery of Cast Iron Cement—The Discovery that a Burning Starch Factory Yielded—Muddled Calico-printers—A Quaker Railway Clerk's Happy Idea.

IN the ordinary affairs of life we are often compensated for not finding what we seek by the discovery of something still more valuable that we have not looked for; so, in an accidental way, inventors have frequently stumbled upon surprises and revelations which have produced results more tangible than the particular object of their search would have yielded them if discovered.

One of the earliest recorded instances of inventions discovered by accident relates to glass, which, according to Pliny, was the outcome of an incident that occurred on the coast of Phœnicia in a very remote age. Some merchants were encamped near Ptolemais, between the foot of Carmel and Tyre, at a spot where the river Belus washes to the shore the fine sand which it brings down from the hills. At this place, the story goes, they kindled a fire, and having nothing better than the bags of nitre with which their ship was laden to suspend their cooking vessels upon, they reluctantly used them for that purpose. Presently, the fire fused the nitre and the sand, and their eyes were gladdened by the sight of sheets of glass. It is said that the Sidonians took advantage of the discovery and cultivated the art of glass-making with great success, acquiring wealth and fame by it.

In the early history of pottery several instances of accidental discoveries occur. It is related of one potter that by noticing a cloud of calcined flint blown in his horse's face, he obtained the idea of adopting silica as a constituent in his ware; and that the servant of another potter gave her master the notion of salt glaze by allowing an earthenware pan full of brine for the preservation of meat to boil over, showing, by the action of the intense heat, the alkali combining with the earth and forming a vitreous surface.

Accident must have been a great help to invention in the early times before the mechanician had become such a power in the world. As we have seen, it had much to do with assisting the operations of those scientific dreamers, the alchemists; while in more recent times it has often been the means of greatly accelerating the work of discovery and invention. The oscillations of a lamp served to set the genius of Galileo on the track of important discoveries; and the falling of an apple taught Newton the principle of gravitation.

The telescope was an accidental discovery. The children of a Dutch spectacle-maker named Lippershey were playing with some of their father's glasses before his door, setting them this way and that, and peeping through them in turns for fun, when by a certain accidental arrangement of the glasses they were surprised to see the spire of the distant church brought, to all appearance, close to their eyes. The spectacle-maker was called to witness the phenomenon, and was filled with a strange delight with what he saw. He from this set about the construction of the telescope, and, when it was finished, took the instrument to Galileo, who improved upon it, and astonished the Doge and the nobles of Venice by one day presenting it to their wondering eyes to look through.

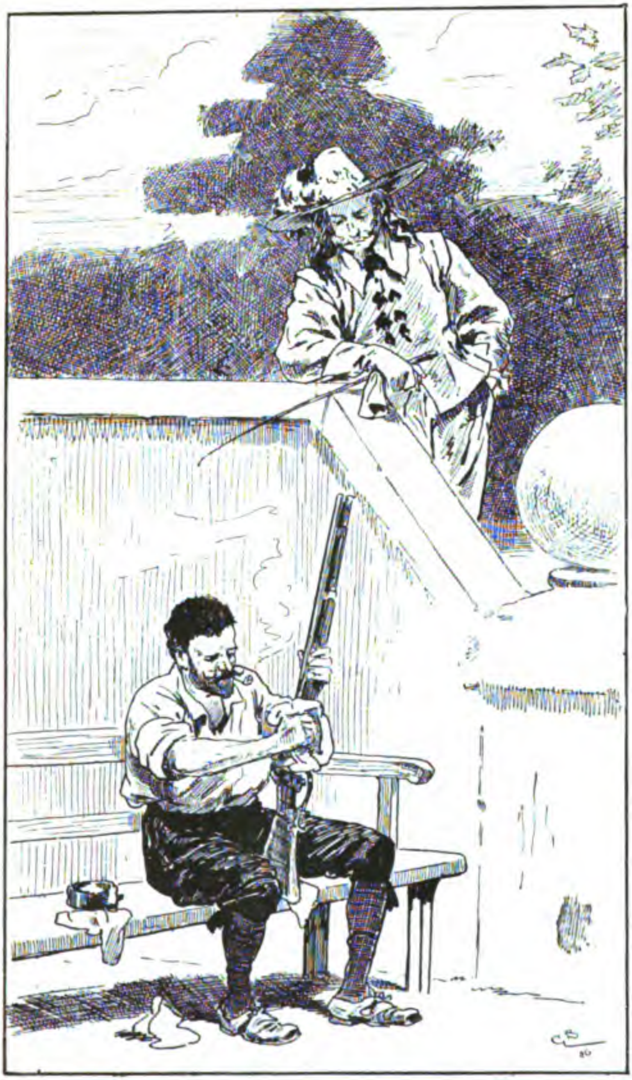
The steam-engine, which, taken as a whole, is the finest invention that the world has seen, owes much to accident. The Marquis of Worcester is said by one authority to have had his attention originally drawn to the subject of steam power, by the cover of a vessel filled with hot water having been blown off before his eyes while he was undergoing imprisonment in the Tower. Not very long afterwards, towards the latter part of the seventeenth century, Captain Savery, a gallant Englishman, was at Florence. He loitered in a tavern there one day, and, calling for a flask of wine, drank it off and then threw the empty bottle into the fire, in an absent, careless sort of way. Immediately afterwards, a few drops of wine that had been left in the bottom of the bottle began to issue forth in steam, startling the Captain a little. He seized the bottle from the fire, and plunged it, neck downward, into a basin of cold water that happened to be at hand. The water rushed up into it, almost filling the flask. This set the Captain thinking, and his thinking set him experimenting, and in the year 1698 he took the first practical step towards the steam-engine by taking out a patent "for raising water and occasioning motion to all sorts of mill-work, by the impellent force of fire." Then followed the historic steam-engine of Thomas Newcomen, in the development of which accident again more than once came to the rescue. One day, in 1705, Newcomen and Crawley's engine was grinding away in its ponderous fashion, doing its work much as usual, its cylinder being cooled after each stroke by the application of water to the cylinder *outside.* Suddenly, without any apparent cause, the engine started off at an increased rate of speed that alarmed the engineers. Then it as suddenly stopped, and the proprietors exchanged looks of half-comic bewilderment. What could be the matter? They proceeded to make an investigation. The engine had darted off without any supply of water to the condensing jacket, and they found, on examining the piston, a hole through which the water—poured on it to keep it air-tight—had issued in the form of a jet and instantly condensed the steam within. From that time the water-jacket was no longer necessary; water was supplied to the interior of the cylinder by a pipe.

There was something of accident in the invention which Humphrey Potter, the lazy cock-boy, brought about at a subsequent period. The regulating and condensing valves had in those days to be shut and opened by a boy kept for that purpose. Humphrey, however, cared more for play than work, and one day, in order to escape his task, and get away into the fields, he conceived the idea of connecting the levers which governed the cocks with the beams by a piece of string. This idea he carried into effect, and then off he scampered. His absence was discovered, and so was his ingenious contrivance. No doubt he was freely forgiven and promoted, though we do not hear anything of him afterwards. For once idleness had done a great service to mechanical science, the principle of Humphrey Potter's labour-saving invention being ever after adopted in the working of the steam-engine, which this improvement rendered completely automatic.

Then there was something almost accidental in the discovery by Watt, the greatest mind that coped with the steam problem, of the theory which he ultimately applied with such success. It was while walking on Glasgow Green one Sunday afternoon that the thought struck him that steam, being an elastic vapour, would expand and force itself into a previously exhausted place. He used to point with pride to the exact spot where this happy inspiration occurred.

Schwanhard, the Nuremberg glass-cutter, discovered the art of etching on glass by the accidental spilling of some aquafortis on his spectacles, which caused them to corrode and turn soft. From this he learned to make a liquid by which he could delineate and etch on glass figures and ornaments of all kinds. The discovery of fluorspar, the only other acid that will corrode every kind of glass, was made by Scheele, in 1771. Up to Schwanhard's time glass had been mainly manipulated with the diamond, Francis I., of France, being quite abreast of the invention of his time when, with his diamond ring, he wrote upon a pane of glass in the Castle of Chambord, for the special edification of Anne de Pisseleu, Duchess d'Éstampes, the words by which he proved to her his jealousy.

Berthollet, examining the corks in which Scheele had been bottling up his chlorine gas, discovered a new secret of bleaching, whereby an important process which had previously required months to complete could be performed in a few hours. Courtois, the French soap-boiler, found iodine in his sea-weed ash; Senefelder—as we have seen—arrived at the



Prince Rupert and the Soldier.

art of lithography through the accidental use of a chemical ink and paper that he had prepared for copper-plates; and we have told how Argand's lamp was perfected by the accident of his young brother mischievously placing a bottomless oil flask over every article in the work-room that permitted such an operation, and finally upon the flame of the lamp by whose light Argand was studying, which shot up with added brilliancy, and suggested the idea of the lamp chimney. The Montgolfier balloon was the result of an accident with lighted paper; and Dr. Priestley's creation of the science of pneumatic chemistry was the outcome of his observation of the effect of the extinction of some lighted chips in the gas floating over the fermented liquor in the vats of a Leeds brewery, near to which he resided.

Prince Rupert chanced upon an interesting discovery by accident in 1656, when he was living in Brussels. While walking one morning he saw a soldier take up his gun for the purpose of cleaning it. A portion of the barrel was covered with rust, the gun having been left out in the rain all night. The soldier applied a linen cloth to the rusted part, and in rubbing it brought off a coloured pattern, which struck the Prince as being capable of imitation for the purposes of art. On this he began to make experiments, and, aided by Wallerant Vaillant, a printer, invented the mezzotint process.

The discovery of electricity has been traced to an accidental meal of frogs indulged in, under medical advice, by Signora Galvani. It was certainly the cause of the discovery of galvanism. Galvani was professor of anatomy at the university of Bologna, and was in his laboratory making experiments with an electrical machine, when (so the story goes) his wife came into the room with her dish of frogs, and sat down beside him. She had probably little relish for the amphibians; at all events, she does not appear to have been in any great haste to consume them, for while they lay on the table uneaten, an assistant accidentally touched one of the presumably dead frogs with the point of a scalpel, and its crural nerves immediately became violently agitated, giving the creature all the appearance of restored animation. The wife observed this incident with surprise, and, drawing her husband's attention to it, he repeated the dose upon the poor frog, and the discovery of what subsequently came to be known as galvanism was established. Signora Galvani's frog-soup was the means of giving the world a new system of physiology. Volta took the matter up where Galvani left it, and, after a series of investigations and experiments, succeeded, in 1800—ten years subsequent to the frog incident—in introducing his famous invention of the Voltaic pile, or compound Galvanic Circle. It was Volta's contention that the existing fluid was electricity, produced by the contact of two metals, and that the convulsions of the frog arose from the electricity thus developed passing along its nerves and muscles. The force which produced these phenomena, he proved, was generated by the contact of heterogeneous bodies, which decomposed their natural electricity at the point of juncture continually separating the two fluids, making the positive electricity pass along the one and the negative along the other, establishing the fact that every two heterogeneous bodies formed a galvanic circle or "arc."

In connection with the art of war there have been one or two accidental discoveries made of an interesting description. The bayonet was the result of an accidental circumstance. A regiment of Basque soldiers found themselves hard pressed on a mountain ridge near Bayonne. They had spent their ammunition, and the foe was upon them. Driven to the verge of despair, one of their number suggested that they should fix the long knives, which formed part of their ordinary equipment, into the barrels of their muskets. This was done, and the first bayonet charge was made, with a victorious result. The military authorities saw the advantage of the improvised weapon, and before long the bayonet was introduced into all European regiments of infantry. It was adopted in the British army in 1672.

Lead shot, we are told, was the result of a vision. A Bristol plumber named Watts dreamed that he was doing some repairs on the roof of the church, soldering up some defect or other, when, his foot slipping, he let the ladle of boiling metal fall into the street below. He dreamed also that he went down there and then to pick up his ladle and lead, but when he got to the spot where it had fallen he found something very different from what he had expected. The ladle was there intact, but the molten lead, instead of being there in a silvery pool, as he had imagined, was represented by myriads of tiny globular congelations. When he awoke and found he had only been dreaming he was disappointed, not to say annoyed, and sought consolation by taking up his tools of trade, walking forth, and repeating as faithfully as he could the details of his dream The result was precisely the same waking as dreaming. Watts saw his way to lead shot, made an invention of it, and, it is said, made £10,000 by his dream.

In the last century fashion was furnished with a new style of dress material, to which the term "water-tabby" was given. For a while "water-tabbies" were the rage, and their inventor is said to have made his fortune by them. The accident of their discovery was not a matter for pride, by any means; in fact, there was a suggestion of nastiness about it. The inventor was a tailor. One day while walking over a piece of floor-cloth in his workroom he expectorated upon it. He must have been immediately sorry for this offence against cleanliness, for he took up his heated "goose" and placed it over the spot. Lifting the implement up again he was astonished to see that a very beautiful pattern had been formed upon the oil-cloth. He did not neglect the hint, but started a series of experiments with hot irons and water, that resulted in "water-tabbies" for the world of fashion and a fortune for himself.

Cast-iron cement was the outcome of accident, which fell in the way of William Murdoch at the time he was with the firm of Boulton and Watt. Looking into his tool-chest one day he found that some iron-borings and sal-ammoniac had got mixed together, "and rusted his saw-blade nearly through." He forthwith began to experiment with the two substances, and ultimately produced the cement in question, which afterwards became an important article of manufacture at the Soho Works.

Another accidental discovery fruitful in importance was made in the village of Chapelizod, near Dublin, in 1821. His Majesty George IV. had been making a royal progress through the sister isle, and on the 5th of September in that year embarked for England at the harbour of Dunleary, amidst many manifestations of loyalty. The local authorities did honour to the occasion by changing the ancient Irish name of Dunleary to that of Kingstown, and the light-hearted citizens of Dublin gave themselves up to enjoyment and consumed large quantities of the national beverage in drinking their own and the King's health. Whilst the conviviality was at its height that evening, a sudden cry of "Fire!" was heard, and the people rushed into the streets to discover its whereabouts. A starch factory on the banks of the Liffey, near Chapelizod, was in flames, and amongst the persons who ran to the scene was a certain journeyman calico-printer, who had been making merry in one of the taverns. Following with the stream of people, he presently found himself, by no means sober, in front of the burning factory helping in the work of pumping water upon the doomed building. The water washed the starch out into the roadways until the people were ankle-deep in it, and, in the confusion of extrication, the calico-printer got entangled with some of his neighbours, and had many a tumble and roll amongst the puddles of starch before he got away.

Next morning he awoke with a sense of headache and weariness upon him, and started to dress himself; but somehow all the apertures for his limbs were closed, his garments were stuck together in every part, as if they had been dipped in glue, and much had to be done in melting and slitting and cutting before he was able to make his way into his clothes with any degree of satisfaction. He was so bewildered with the business that he paid a visit to some shopmates to talk the matter over, and found that they had been much in the same plight. They walked across to the scene of the fire, and were surprised to see the roadway in a state of sticky puddle. As calico-printers, they knew only too well the value of the gum-arabic which was so largely used in their trade, and to them it seemed that this soft glutinous mixture lying in the streets was equally suitable for the print-works. They took some of it away and tried it in their trade, with the most gratifying results. Then they began to experiment with common starch: burned it in a frying-pan, put water to it, and in the end found they could by this simple process produce a gum that, for all practical trade purposes, was as good as gum-arabic, and at a fraction of the cost.

Money was scraped together to send one of the six men who possessed the secret to Lancashire to negotiate for opening up a market for the new gum. He did not succeed very well, however, probably because he was seldom sober when he called upon the parties with which the gum syndicate desired to do business. More money was raised, and another member of the band was despatched after the first one, and, as the two together did not manage to improve matters, the remaining four thought it advisable to proceed to Lancashire also. They were right in supposing that they possessed a secret from which fortunes might be made for all of them, but they were utterly incapable of developing their discovery on correct business lines. Being anxious, above all things, to secure some ready cash, they at last resolved to sell their secret, and, with that view, opened up negotiations with a gentleman in the cotton trade. But before the transaction could be completed one of the men died, and other two were sent to prison for being concerned in some drunken riots in Manchester. The other three men contrived to conclude a bargain of some kind with the gentleman with whom they had been in treaty, and with the money thus obtained, whatever it was, they proceeded to New Orleans, where they speedily got to the end of their means, and no more was heard of the first discoverers of British gum. The gentleman, who ultimately turned the secret to a profitable account, made money of it and kept it to himself for a while; but all kinds of tricks were played upon him for the purpose of discovering it, his place being broken into at one time and at another time burned down; and he was at last betrayed into allowing a customer to watch his operations, and then the secret got out. It was this British gum that enabled postage-stamps to be produced in an adhesive form on the introduction of the penny postage system.

In the summer of 1840 a railway clerk named Thomas Edmondson, a Quaker, who was employed at a small station on the Newcastle and Carlisle line, was taking a walk in a Northumberland field, thinking of nothing in particular, but just strolling leisurely along, as he had done scores of times before through the same field in the same way. He looked on the ground too much to be altogether a happy man. In truth, he was discontented, for he had failed in business not long before, and the shadow of this misfortune still saddened his heart. As he went on his way, moodily putting one foot down before the other, a sudden thought brought him to as sudden a stop, and he lifted his foot from the ground and stared, like one who saw a golden vision, at the marks which his rather substantial boot had left imprinted there. He had been touched by a flash of inspiration. The idea of the pasteboard railway ticket had leaped into his brain—a complete creation. Up to that time railway passports had consisted of printed forms, which had to be filled up by the station clerks with pen and ink, for every passenger, according to date and destination—a tedious process. The Quaker clerk now saw as clear as day how tickets could be printed with the names of stations, the class of carriage, and the dates of the month, on one uniform system from end to end of the kingdom. The new notion was soon put into operation, and exists to this day on all the railways of the world much the same as it had occurred to Mr. Edmondson while walking through the Northumberland field.

In connection with this idea the ticket-printing machine, the checking machine, the dating-press, and the issue-cases, were invented; and the Railway Clearing House system was established, whereby passengers can travel from one line to another over the various railway systems which run in connection without the trouble of getting fresh tickets at various points of a journey, as had to be done in the early days of railways, the companies now acting in unison for the convenience of passengers generally, and settling amongst themselves their claims to their respective shares of the ticket money. An ingenious watchmaker named Blaylock, a friend of Edmondson's, worked out the mechanical ideas, and their names were associated in the different patents that were taken out. Mr. Edmondson's invention was first adopted by the Manchester and Leeds Railway Company, and he was employed by them for a time at their Manchester station in Oldham Road. Other companies also arranged for the use of his invention, and he had before long to withdraw himself from clerkship altogether and take charge of an establishment of his own for the providing of tickets and machines to meet an ever-increasing demand. He charged the companies ten shillings per mile per annum for a licence to print their own tickets by his apparatus, and was at once on the highway—or railway—to fortune. The shadow of trouble was now lifted from his life, and the first use he made of his influx of wealth was to clear away the stain of the Bankruptcy Court from his name and pay every shilling he had ever owed. He lived only twelve years after the introduction of his invention, dying in 1852, at the age of fifty-eight, having enjoyed the honours and emoluments of his genius with a modesty that became his Quaker parentage.

CHAPTER XVIII.

THE REVELATIONS OF WHEEL-LAND.

Primitive Wheels—Ancient Chariots—The Ancient Briton as a Chariot-builder—The Introduction of Four-wheeled Vehicles—Roads in Feudal Times—Covered Carriages of State of the Sixteenth and Seventeenth Centuries—The First Coach—English "Whirlicotes"—Incorporation of the Coach-and-Harness Makers' Guild—Pepys Reports upon some New Carriages—The "Boot"—"Stuck in the Mud"—Flying Coaches—Coaches *versus* Sedan Chairs—Pleasure Carriages—English State Coaches—*Carosses à cinq sous*—The First London Omnibus—Road Locomotives—The Beginning of Railways—George Stephenson—"Good-night to Feudality"—Trevethick's "Devil"—Edward Pease projects the Stockton and Darlington Railway—The First Train—The Liverpool and Manchester Scheme--The Railway Mania—The Railways of To-day—Wheel-land in Miniature.

BUSY as invention has been with wheels since the discovery of their original prototype—a circular slice from a tree-trunk, with a hole drilled in the middle for the reception of an axle of some primitive kind—we do not need to travel far to find specimens of wheels of this description still in use. In the remoter rural districts of many countries, where the spur of commercial activity is wanting, there are yet employed vehicles almost as simple as this first cart must have been; but, while wheeled contrivances have been unprogressive where primitive habits still linger, as soon as we touch historical record, and trace the growth of civilisation, we find plenty of evidence of vehicular advancement.

For thousands of years wheeled conveyances seem to have remained much the same. The chariot of Pharaoh, or of Nero, or of Boadicea, did not differ widely in mechanical construction from the ruder vehicles used by the peasants for agricultural purposes. They were built of costly materials and adorned with a profusion of ornament, but, for the rest, they showed little novelty. Pharaoh considered it an act of condescension to permit Joseph to have the use of one his kingly chariots; Nero fancied himself achieving a vehicular triumph when he harnessed ten horses abreast to the chariot in which he rode to the public games; and Boadicea felt all the more a heroine for being able to urge her warriors to battle from the vantage ground of her best war-chariot. All these boxes on wheels, however, were as simple in construction as is the *barco de terra* of the Pampas of La Plata to-day, or as was the Egyptian cart used in threshing corn. As for the Anglo-Saxon chariot, it has been said, "without meaning to insult the memory of our warlike ancestors, this chariot has, nevertheless, a striking resemblance to a donkey-cart in use in our country villages;" and yet this was probably "the moving platform from whence Boadicea with her injured daughters harangued the brave though undisciplined Iceni."

Britain, uncivilised as it appeared in the eyes of the luxurious legions of Cæsar, was able to teach the noble Roman a lesson in the art of chariot-building. Cicero expressed the opinion that there was little in the island worth the trouble of transport to Rome except the British war-chariot, which in point of workmanship and decoration was vastly superior to the chariot of Gaul and Belgium, as well as of Rome. The British chariot, with its coachman on the pole, and half-a-dozen grooms running by its side, made such a sensation in the imperial city that it speedily became the rage, and all who could afford the cost possessed themselves of one. The perfection of chariot-building was reached by the Britons of Cæsar's time, who so excelled in the art that it became one of their leading industries.

For a long time there were no other vehicles than those which were of two wheels and open. Then came conveyances of four wheels, which implied a degree of inventive ability far in advance of what had been done before in this direction. Four wheels of equal diameter, and without turning arrangement for the front pair, could not have existed long; the difficulty of rounding corners easily would soon suggest smaller front wheels, with their axle turning on a pivot. The next improvement was a crane-neck iron beam, "adjusted over each front wheel, enabling the perch-bolt to be used without much, if any, lengthening of the vehicle." The Pompeian wine-cart was, according to the frescoes on the walls of the long-buried houses of that ancient city of luxury, a four-wheeled arrangement, with wheels all of equal diameter, but with an arched space in the centre to make the turning of the front pair easy. The four-wheel system having once been established, the covered carriage would be the next development. At first the enclosed conveyance was used only for sick people. This was called by the Romans the *arcera*. The *lectica*, which came next, introduced an additional luxuriousness, and ultimately superseded the *arcera*. After that followed the *carrucæ*, which were of such magnificence that they were by the Theodosian Code commanded to be used by civil and military officers of the first rank as a mark of dignity.

We do not get any great improvement upon the

Roman carriages for a few centuries. The feudal period was not favourable to vehicular traffic. For one thing, the roads were in a wretched plight, rendering it almost impossible for carriages to make their way through the mud and mire, the sloughs and bogs; and, for another thing, the conditions of military service were such as to make riding on horseback of the first importance. So carriages of every description were for a while discarded, and horses, mules, and asses sufficed for all the purposes of travel. The noble rode to battle, the monk rode to prayer, the minister rode to court, knights and ladies rode to the tournament, and the merchant rode to market. What an interesting collection of riders we have in Chaucer's "Canterbury Pilgrims"!

It was not until the beginning of the sixteenth century that covered carriages were re-introduced, and then only out of compliment to the ladies, gentlemen considering it beneath their manliness to go otherwise than on horseback. But, bit by bit, the custom of riding in carriages was resumed, and from being at first patronised only by persons of exalted rank came into more extended use by people of fashion generally. Beckmann mentions a number of instances of close carriages or coaches having been used on different State occasions in the sixteenth and seventeenth centuries, when the feudal spirit was beginning to die out. At the tournament held by Joachim, Elector of Brandenburg, at Ruppin, in 1509, the Electress rode in a carriage "gilt all over," and there were twelve other coaches ornamented with crimson, and one hung with red satin. The Elector of Cologne made a great display with a dozen carriages at the coronation of the Emperor Maximilian in 1562; and in 1594, when the Margrave John Sigismund did homage at Warsaw on account of Prussia, he had thirty-six coaches, each drawn by six horses, in his train. When the Emperor Ferdinand II. was married, "the bride rode with her sisters in a splendid carriage studded with gold; her maids of honour in carriages hung with black satin, and the rest of the ladies in neat leather carriages." On the occasion of the marriage of the Emperor Matthias, in 1611, his consort made her public entrance in a carriage covered with perfumed leather. The first mention that history makes of the sort of fairy coach associated in the popular mind with the pretty legendary story of Cinderella is in connection with the entrance of Mary, Infanta of Spain, into Carinthia, in 1651, when she rode in a carriage of glass in which no more than two persons could sit. In the time of Francis I. there were only three coaches in all Paris, one of which was used by the queen, another by Diana of Poictiers the King's mistress, and the third by Réné de Laval, a corpulent nobleman who was unable to ride on horseback. Catherine de' Medici is credited also with having indulged in a coach. Henry IV., we all know, was assassinated while riding in his coach, which, by the way, was the only one that he and his queen had, inasmuch as he one day excused himself from visiting a friend by writing, in a letter still extant, "I cannot wait upon you to-day, because my wife is using my coach." The coaches of those days had a canopy supported by ornamented pillars, the whole body being enclosed by stuff or leather curtains. They were not suspended by straps, as at a later date. Louis XIV.'s carriage was a suspended one.

There is a tradition that the first coach was built in a place called Kotze, in Hungary, hence the name "coach." Other countries put in a claim to having originated this vehicle; but there is not sufficient reliable testimony to enable one to decide which nation is entitled to the honour. "Whirlicotes" were the first carriages used in England. The mother of Richard II. rode in one, owing to sickness, when that monarch took to flight; but such vehicles were used only on great public occasions. Not until the seventeenth century did coaches come into anything like general use in England. In truth, the introduction of the vehicle was looked upon with great disfavour in some quarters. One writer complained that "now the use of these coaches brought of Germany is taken up and made common, great ladies caused coaches to be made for them, and rid in them up and down the counties to the great admiration of all the beholders, and little by little they grew usual among the nobility and others of quality, so within twenty years there grew up a great trade of coach-building in England." Taylor, the water-poet, denounced coaches with all the bitterness of one interested in their suppression. He declared that the trade of the watermen had been ruined by coaches, which he described as machines in which people were "tost, tumbled, rumbled, and jumbled without mercy."

The first coach made in England, says Mr. Thrupp—no mean authority—was made in England in 1555, "for the Earl of Rutland, by Walter Rippon, who also made a coach in 1556 for Queen Mary, and in 1564, a state coach for Queen Elizabeth." The Earl of Arundel is said to have brought over a coach from Germany in 1580 for her Majesty; but Elizabeth preferred one that had been imported from Holland in 1560 by William Boonen, who filled the office of coachman, while his wife held that of starcher to the Queen, he having introduced a Dutch coach, she the Dutch method of clear-starching, by which Queen Bess's famous cambric ruffs were got up to look most captivating.

Coach-making had become so important an industry in the time of Charles II. that the coach and harness makers' guild was incorporated. This was in 1677. Coaches were now a necessity, for people had grown lazy and luxurious under the rule of a monarch whose highest sense of duty was pleasure. They were no longer a mere fashionable display, as had been the case when the Duke of Buckingham, in 1619, astonished the citizens of London by appearing before them in a magnificent coach drawn by six horses, a bit of vanity that the Earl of Northumberland outdid immediately afterwards by harnessing eight horses to his carriage.

It was now that the inventor began to set his ingenuity to work on behalf of carriage-people. Pepys mentions the fact of his attendance at a series of experiments "about the making coaches go easy," in May, 1665. "Several we tried," he says, "but one did prove mighty easy . . . and we all one after another rid in it, and it is very fine, and likely to take." The spring had been introduced, but "the whole of the body lay" on one long spring. Colonel Blunt invited Pepys shortly afterwards to try his new chariot with springs, and the observant diarist says: "So for curiosity I went in it to try it, and up the hill to the heath, and over the cart ruts, and found it pretty well, but not so easy as he pretends." Still another new vehicular contrivance was brought under the notice of Pepys, the following year, "where the coachman sits astride upon a pole over the horse, but do not touch the horse, which is a pretty odd thing."

In the seventeenth century many valuable improvements in coach- and carriage-building were introduced, but so gradual were the changes that we do not possess any special information respecting the men who invented them. We do not even know who was the inventor of coach-springs, or to whom we owe the "boot," or why, indeed, the term "boot" was originally applied. Derivation-hunters have puzzled themselves over this name more than enough. A carriage that Queen Elizabeth used for her attendants had "boots" at the sides, and the first stage coaches were fitted with "boots." The water-poet wrote: "It means two boots and no spurs; sometimes having two pairs of legs in one boot; and oftentimes against Nature, most preposterously, it makes fair ladies wear the boot. Moreover, it makes people imitate sea-crabs, in being drawn sideways as they are when they sit in the boot of the coach." It is evident that passengers used to ride in the "boot" in those days.

In the eighteenth century wheels were running about England in all directions; at all events, as fast as the bad roads would let them, for the advent of the ingenious Macadam, the saviour of roads, was still a long way off, and England was as completely "stuck in the mud" as ever any country could be. Yet this was the great stage-coach era, when travel was a thing of romance and adventure; when people made their wills before setting out on a journey; and when, amongst the incidents of the road, the rest and repast at the cheery roadside inn, and the night encounter with the highwayman in some lonely part, had to be accepted in contrast one with the other as equalising experiences. The glamour of poetry has been thrown over that eventful period of travel, and from Fielding to Dickens the spirit of fiction has exercised its loving fancy upon the humour and excitement, the picturesqueness and sentiment, of coach-riding. Without the stage-coach Tom Jones would not have been half the hero he was, and Sam Weller would have run the risk of almost being commonplace.

The first "flying coach" was established in 1754 to run between Manchester and London, and it was thought that the utmost limit of speed had been attained when these much-distrusted and supposed dangerous conveyances performed the journey from Manchester to the capital in four days and a half. People did not look very far ahead in those times, for they seemed so well contented with things as they were, that they greatly objected to have them improved. The proposal for the extension of turnpike roads met with the most violent opposition. All sorts of vested interests were up in arms against such an interference with the ancient privileges of sticking in the mud. Even the Blandford waggoner of the anecdote book emptied the vials of his wrath upon the people who wished to mend the roads for him. "Roads on'y be good for one thing," he said, "an' that be waggon-drivin'. I on'y want vour-foot width in a lane, an' arl the rest may go to the devil. The gentry ought to steay at whoam, rot 'em, an' not run gossippin' oop an' deown the country."

But the inventors had now got fairly amongst the wheels, and there was no likelihood of their leaving them yet a while. Coaches continued to be improved, and roads too, the enterprising Mr. Palmer at last rousing the country out of its lethargy and stagnation by starting his daring project of mail coaches that should travel at the tremendous rate of from eight to ten miles an hour.

Luxury was the first to be ministered to by the wheelmen. Colonel de Chiese, in the service of Frederick William, Elector of Brandenburg, about the middle of the seventeenth century had invented a new carriage for two persons, to which the name of the "berlin" was given. About the same time the *fiacre* was introduced in Paris, and other hackney carriage systems were adopted in London, and other places. The increase of wheel-power obtained by these various inventions was very great. M. Dupin, of Paris, had towards the latter part of the seventeenth century, invented a new kind of vehicle called the *brouette*, or *roulette*, which was a compromise between the sedan chair and the carriage—a sedan on wheels, in fact—and, although at first violently opposed by the chair-men, won its way into favour and was largely used.

Between the new carriages and the sedan-chairs, the beaux of the eighteenth century had an embarrassing choice, but the wheeled machines outlived the coach on poles, for the wheels meant action and progress, while the sedan-chair indicated ease and retrogression.

The pleasure-coach had even more attention given to it than the stage-coach, for the latter did not change its design or improve its capacity to any considerable extent from the flying-coach period down to its last dying stages, when it dropped from the high road, as the railroad chased it from all its time-honoured haunts, and it was only heard of again in remote places inaccessible to railways.

There is great kinship between the various pleasure-vehicles invented from the time of the berlin to our own day. There was the landau, so named from the German town which gave it birth, which still remains a favourite vehicle, because of its capability of being used either as a closed or an open carriage. There was the landaulet, a smaller landau; there was the barouche, and the barouchet, which the French gave us; the britzschka, which came from Russia; the phaeton, which belongs to the same group; the French cabriolet; the *vis-à-vis*; the Russian drosky; and the curricle. The curricle, as one of the few two-wheeled conveyances admitting of two horses abreast, was very fashionable in the time of the Prince Regent. Romeo Coates had a curricle built of copper, in the form of a sea-shell, which was something of a sensation in its day. Another dandy, Count d'Orsay, used to drive a curricle. The tandem was another two-wheeler, with two horses, one in front of the other. The suicide was a high tandem gig, "in which the groom was mounted on a seat three feet above the driver." Then there was the sulky, which *voiture à l'Anglaise* the French copied; and this was followed by the sociable. The stanhope, named after a noble lord who did *not* invent it, proved to be a great improvement upon the old mail phaeton. An inventor's name is represented in the tilbury, a variety of the cab *genus*. The gig, the dog-cart, the fly, and the buggy, are all well-known varieties, the last named being of American origin, and remarkable for its combined lightness and durability.

The cabriolet was the fashionable two-wheeled conveyance of fifty years ago, but it has now passed away, the brougham, which was invented in 1839, hastening its departure from the scene. Lord Brougham actually gave the idea of this handy little coach, which has been happily described as "affording the maximum of appearance and convenience at the cost of one horse and servant." Something approaching in construction to the brougham was in use in Birmingham and Liverpool a few years before under the name of one-horse cars; but a four-wheeled carriage drawn by a single horse was entirely unknown in the fashionable world until the introduction of the brougham. The dennet deserves mention for the fact that it "was so called because the three springs were named after the three Miss Dennets, whose elegant stage dancing was much in vogue about the time this vehicle came into use."

The four-in-hand drag is a variety of the stage-coach; the waggonette is an adaptable, easy-going improvement on the French *char-à-banc;* the pony-phaeton—one of the few good things which the Fourth George patronised—is the humble but acceptable offspring of the phaeton proper; the coburg and the whitechapel are members of the gig order; and the victoria and the clarence are carriages in which new developments of old ideas have borne good fruit. The cab, or diminutive cabriolet, with its four wheels, single horse, and single driver, was an invention that proved a valuable adjunct to the railway system which was throwing its network of iron across the length and breadth of the land at the time of its introduction. Then came the hansom, the "gondola of London," as Lord Beaconsfield called it, which was imported from Naples and took the name of its introducer.

The Irish jaunting-car is a conveyance of a unique character, well suited to the country of its adoption, and partaking of some of its humour. The car system was introduced by Charles Bianconi, a young Italian, who at the time the idea struck him was an itinerant print-seller. It was from carrying his heavy loads of pictures on his back that he set himself the task of inventing a car system which should give the poor as well as the rich "the opportunity of travelling comfortably," and it was a favourite saying of his that his great car establishment "grew out of his back." Previous to Bianconi's time, the traveller had to catch the jaunting car as best he could, and take it for what it was worth when he had caught it. As a one-horse vehicle capable of tackling any kind of road, it would, however, be difficult to beat the Irish jaunting-car as it has been perfected by Bianconi and others. The peculiar humour of the Irish character is never more fully brought out than under the excitement of a drive on one of the native cars. It has been said that the intelligence of the Irish car accounts for its popularity. "It would follow a horse anywhere," says Dr. Edgeworth.

Amongst the wheeled conveyances upon which the inventor has spent much talent to no very great purpose may be mentioned some of the State-coaches of European sovereigns, which are, perhaps, more remarkable for their costliness than for their comfort or elegance. The Queen's coach of State was designed by Sir William Chambers for George III. Horace Walpole declared it to be a beautiful object, though somewhat too crowded in its adornments. It cost the nation upwards of £7,000. The Lord Mayor's coach dates a few years farther back. Its panels are adorned with allegorical pictures by Cipriani. The Speaker's coach is a fine example of seventeenth century workmanship. It is mounted on four groups of allegorical figures, and the oak framework is carved with foliage and figures. Oliver Cromwell is said to have used this coach. The collection of State-coaches in the South Kensington Museum sufficiently attests the splendid discomfort and ponderous elegance of the infancy of coach-building. The equirotal was a carriage invented by Mr. Adams, which the Duke of Wellington showed his belief in by using up to the time of his death. It passed away with him, however, being, perhaps, too ingenious for ordinary persons and purposes. The forepart and wheels were connected with the hind body by a hinge or joint, so that the driver always had his horses square in front of him no matter how they turned. "Complete, it was a landau, holding four inside, beside the servant's hind dickey; disunited, it formed at will a stanhope gig, a cabriolet, or a curricle."

The omnibus marked an important advance in the art of travelling by wheels. This vehicle of town transit was introduced to London in 1820, and appears to have been an adaptation of the *Carosses à cinq sous* of the time of Louis XIV. The latter were started by a company, in 1662, which had the Duc de Roanes for its head, and no less a person than the gentle Pascal among its shareholders. The royal decree set forth that these coaches, of which there were originally seven, each containing eight places, were to run at fixed periods, full or empty, for the benefit of "a great number of persons ill-provided for, as persons engaged in lawsuits, infirm people, and others, who have not the means to ride in chaise or carriage, which cannot be hired under a pistole or a couple of crowns a day." At seven o'clock, on a raw March morning of the year 1662, the public inauguration of the new *carosses* took place, when two commissaries of the Châtelet, in legal robes, four guards of the Grand Provost, half a score of the city archers, and the same number of cavalry, assembled on behalf of the King, and added the dignity of authority to the scene. Each coachman was attired in a long blue frock, with the arms of the King and those of Paris embroidered in brilliant colours on the front thereof. It is said that even the Grand Monarque himself took a trip in one of these *Carosses à cinq suos*, which became very popular, and the actors of the Marais amused their audiences for a considerable time with a laughable piece called the *Intrigue des carosses à cinq sous*. But, in spite of all this, the new vehicles had but a short-lived success. The people of fashion grew tired of them, and when fashion frowned on them the poorer classes declined to accept its leavings, and the wheels of the *carosses* ran the company into failure, and themselves off the road. The company which, on the eve of the railway era, introduced improved *carosses* to London under the name of omnibuses, met with better success, and every leading city in Europe and America speedily adopted the notion, until now riding on wheels has become as common a thing as walking. The latest development of the public carriage movement has been the introduction of the tramway system, by means of which some of the advantages of ordinary railway travelling are imported into the streets. Indeed, on many tram-lines the locomotive has been adopted as the propelling power, and it may safely be predicted that it will ultimately supersede horses for this purpose. A noiseless tram-locomotive is already an accomplished fact. Electric tramways, and cable tramways for steep gradients, are in operation, too, here and there, and, one way and another, the work of invention in wheel-land continues to make very rapid progress.

We have yet to touch upon the principal province in the realm of wheel-land, and that is the vast, far-spreading region of railways. With a history that extends back only about sixty years, steam locomotion has accomplished more towards conquering time and distance and civilising the world than all the other forces utilised by man put together. Science, religion, literature, all sneered at it, to begin with. When George Stephenson proposed to make a railway over Chat Moss, Mr. Francis Giles, C.E., affirmed that "no engineer in his senses" would think of such a thing; clergymen went the length of anathematising the locomotive from the pulpit; and a solid, sober, high-toned publication like the *Quarterly Review*, when the Woolwich line was projected, scornfully asked, "What could be more palpably absurd and ridiculous than the prospect held out of locomotives travelling twice as fast as stage-coaches?" adding, "We should as soon expect the people of Woolwich to suffer themselves to be fired off upon one of Congreve's ricochet rockets as trust themselves to the mercy of such a machine going at such a rate." That thoroughgoing specimen of the unchangeable Englishman, Colonel Sibthorp, denounced Stephenson and all his class as something much less respectable than highwaymen; and there were thousands of less responsible beings who were very much of the same opinion as the Newcastle mail-guard, who, beholding his occupation going with the incoming of the locomotive, lamented that it was all over with England if she was to be converted into a gridiron and covered with tea-kettles! It was something of a consolation to Stephenson, perhaps, to find that, while these reviled and sneered and prophesied disaster, there were men like Dr. Arnott to exclaim, "Good-night to Feudality," and men like Lord Ravensworth and Edward Pease ready to show their faith in the new power by staking large sums of money to assist in its development.

Up to this point the service of the wheel had been to bear, not to pull. One of the first recorded instances of the use of the wheel as a means of propulsion occurs in 1771, when Nicolas Joseph Cuquot invented a road locomotive, and the French Minister, De Choiseul, authorised the construction of the machine at a cost of 20,000 livres. This engine, however, had to be suppressed soon after it got into motion, for it knocked a wall down, and on that account was considered unsafe. In 1772 Oliver Evans, an American, brought into notice a steam-carriage for ordinary roads; and William Symington, one of the inventors of steam-boats, had constructed a similar machine. William Murdoch, James Watt's right-hand man, was also one of the pioneer inventors of the locomotive, he having made one which went on three wheels and was worked by a spirit-lamp. A further step in advance was made by Richard Trevethick, one of the ablest inventive geniuses that England ever produced, and the most erratic. He made a steam-carriage that went tearing away over the

Plymouth road, and sent all the people flying for their lives, for walls and hedges were obstacles that it brushed aside with the utmost ease. This prepared the way for the railway locomotive which Trevethick made and set to work in 1803 upon a tramway at Penydarran, in South Wales, which, with a gradient of one in fifty, succeeded in drawing a load of ten tons. But he, like all other locomotive projectors up to that time, was much troubled by the false notion that smooth wheels on a smooth rail would not bite, and all his engines were hampered by having their wheels jagged or cogged to meet this supposed difficulty. In 1808 Trevethick had one of his improved "devils" exhibited on a circular railway 100 feet in diameter near the site of the present Euston Station, the public being permitted to ride round at a shilling a head at a speed of from twelve to fifteen miles an hour.

After this not much more is heard of Trevethick and his locomotive. Fresh enterprises were in his mind, and other mechanicians were left to complete what he had begun. An engine on his plan was fitted up at Wylam Colliery, near Newcastle, under the direction of William Hedley; and an improvement upon it was patented by Mr. Blenkinsop, of the Middleton Colliery, Leeds. George Stephenson had the opportunity of watching the progress of Hedley's engine, and set his mind to work upon the devising of improvements in it. He obtained the consent of the proprietors of the Killingworth Colliery, at which he was then employed as engine-wright, to attempt the construction of a locomotive engine for them; and in 1813 produced his first locomotive, which, although greatly superior to any other machine of the kind that had been produced, was still cumbrous and clumsy, and far from being the engine that was desired. In 1815 he constructed a second, which was much more successful, and was adopted and put into daily use on the Killingworth tramway for the conveyance of minerals.

As early as 1676 there is mention of a railway at Newcastle-on-Tyne, by means of which coals were conveyed from the pit mouth to the banks of the river "by laying rails of timber exactly straight and parallel, and bulky carts were made with four rollers fitting those rails, whereby the carriage was made so easy that one horse would draw four or five chaldrons." This reference occurs in Roger North's "Life of Lord Keeper North." An iron railroad was in use at the Sheffield Colliery by Mr. Curr about 1776. The first railway authorised by Act of Parliament was that of the Surrey Iron Railway Company, in 1801, for a railway from Wandsworth to Croydon.

In the year 1821 Mr. Edward Pease, a noted Darlington Quaker, obtained an Act of Parliament authorising the making of a railway from Stockton to Wilton. Stephenson waited upon Mr. Pease and offered to undertake the duty of surveying the new line, which was intended only for the carriage of minerals by waggons drawn by horses. Mr. Pease engaged him for the work, and, little by little, as he won the confidence of the shrewd Quaker, the enginewright began to boast of his locomotive, and prevailed upon Mr. Pease to run over to Killingworth to see his "travelling engine" at work. Mr. Pease ultimately became as much enamoured of the locomotive as George himself, and advocated its adoption by the company instead of horses. This provided George Stephenson with the grand opportunity for which he had been earnestly longing; and when the line was opened on the 27th of September, 1825, and George had the delight of driving the first train, which consisted of an engine and thirty-eight carriages, from Darlington to Stockton, he felt that a brilliant career was opening out for him. That first railway train was an oddly-composed freight: six waggons loaded with coals and flour, to begin with; then a passenger coach, which the directors and their friends occupied; then one-and-twenty waggons "fitted up with temporary seats for passengers"; and, to wind up with, half-a-dozen waggon-loads of coals. The speed attained was from four to six miles an hour; nay, in some parts it was said to have reached the alarming velocity of twelve miles an hour! When this train steamed into Stockton that autumn afternoon, with its waggon-loads of coals and flour and some six hundred people "in the train or hanging on to the waggons," the practical application of steam for purposes of locomotion had been clearly demonstrated.

It took five years to gain the next stage of development, and this was effected by the construction of the Liverpool and Manchester line, of which Stephenson had been appointed engineer. He achieved a feat of road-making in taking the line across the bogs of Chat Moss that not a little astonished some of the professional engineers, who were accustomed to sneer at the presumption of the Northumbrian engine-wright, whom they regarded as an interloping amateur. The Liverpool and Manchester line was opened on the 15th of September,

1830. This was a day of triumph for George Stephenson. It had been sought to procure royal patronage for the opening ceremony, but royalty did not as yet know how far it would be safe to smile upon a project which the landed aristocracy regarded with hatred, so it declined to participate in the opening display. The Duke of Wellington, then Prime Minister, Sir Robert Peel, and Mr. Huskisson, were present, and all would have gone well but for an unfortunate accident to Mr. Huskisson. In the flurry of shaking hands with the Duke, between whom and himself there had previously been an estrangement, he got in the way of the engine and sustained fatal injuries. But even this sad accident had the effect of putting the power of the locomotive to a severer test than would otherwise have fallen to it that day. It was the "Rocket"—George Stephenson's prize engine—that struck the member for Liverpool down. Immediately, his other engine, the "Northumbrian," was brought to the spot, and George Stephenson drove the locomotive, conveying the wounded body of his friend, a distance of fifteen miles in the then incredibly short space of twenty-five minutes. A speed of twenty-four miles an hour had been regarded as wonderfully rapid for the formal trial trip, but, when it was a matter of life or death, a rate of thirty-six miles was reached.

There was now a demand for railways between all the great centres of population. A line from London to Birmingham was undertaken, after an expenditure of over £70,000 in procuring the sanction of Parliament to the scheme, which was completed and the line opened in 1838. Within four or five years from the passing of the London and Birmingham Bill nearly all the great trunk lines now existing were begun, and a golden era dawned for Parliamentary counsel. Landowners and canal proprietors fought almost every inch of ground, the former opposing often for the mere sake of getting higher prices for their property, the latter in the hope of averting, or at least delaying, the day of ruin. It cost £14,414 per mile to procure legislative authority for the Blackwall line, and £5,190 per mile for the Manchester and Birmingham railway; and it is said that the solicitor's bill for promoting the South Eastern Railway amounted to £240,000. Everybody was for railways now, and capitalists were ready to invest in any scheme capable of being launched. In 1830 there were only two lines of importance in operation —the Stockton and Darlington and the Liverpool and Manchester — but in 1840 the Parliamentary record showed that no fewer than 299 Acts had been passed, authorising the construction of 3,000 miles of railway. Then there succeeded a lull, and for three years few railway projects were broached; but in 1844 the high dividends realised by the working lines began to tell their tale with the public, and there set in what came to be known as the "railway mania," which brought forth a Railway King—George Hudson, the monarch of speculators—and then ensued a period of speculative excitement which had not been equalled since the days of the South Sea Bubble. The year 1844 saw 797 miles of new lines sanctioned; 1845, 2,883 miles; 1846, 4,790 miles; 1847, 1,663 miles; and there were hundreds of schemes which never got beyond the prospectus stage. Rich and poor, noble and simple, were drawn into the whirlpool, and fortunes were won and lost at an amazing rate.

Retribution followed recklessness, collapse succeeded inflation, and wisdom took the place of folly. Adventurers had to stand aside; and when at last the railway system contrived to shake itself free from the parasites of fanaticism and dishonesty which had fastened upon it, its true greatness and utility came to be recognised, and the process of development was thenceforward steady and natural. The progress of the world was accelerated in every direction by George Stephenson's locomotive. The increase of speed represented by it meant a corresponding increase of activity in everything — increased industries, increased pleasures, increased wealth.

And so the good work of the railway wheels which the humble Killingworth mechanic set in motion on the colliery embankment has advanced, until to-day we have in the United Kingdom alone nearly 19,000 miles of railway in operation, upon which over £800,000,000 have been sunk in construction. These railways, which yield an annual return of £33,700,000 to shareholders and others, give employment to 370,000 persons, and require for their working 14,827 locomotive engines, 33,931 carriages for the conveyance of passengers, 12,514 other vehicles attached to passenger trains, 454,045 waggons for the transport of live stock, minerals, and general merchandise, and 12,236 miscellaneous vehicles. Moreover, the speed of travel which was thought to be of such remarkable velocity when at the opening of the Stockton and Darlington line it reached "at some parts" twelve miles an hour, is now "at some parts" sixty miles an hour, and makes an average speed of 53½ miles an hour for distances of over 100 miles.

The story of the locomotive is a wonderful romance. This machine on wheels has been moving amidst marvels from the time of its first lumbering journey. For its triumphal passage of progress roads have been opened up where roads had never been dreamed of before. It has sped its course from the Atlantic to the Pacific, across the pathless prairies, over the Rocky Mountains, and away through the alkaline deserts of the North West, the buffalo and the Red Indian fleeing from it as from their doom; it has made an endless network of burrows beneath the great world of London; it has rounded the precipitous steeps of the mountain ranges of both hemispheres, climbed Vesuvius and the Righi, and pierced the great Swiss-Italian passes; it has rushed along over the heads of the citizens of New York by a mid-air street railway, characteristic of the daring utilitarianism of the American people; it has dived beneath or made its way above our broadest streams; and has been the incentive to engineering feats of the most marvellous description.

Nor has the world finished with this wondrous tale of magic and romance. Electricity has still to play its part in the fairy story. Already there are electric tramways, and the same power has long been in use for railway lighting purposes. Even George Stephenson, with all his insight and gift of gauging possibilities, could never have imagined half the improvements which, since his death, have been added to the railway system. Modern London, with its 363 railway stations and 260 miles of lines, would have been beyond his wildest dreams; and to the man who put the first primitive passenger car on to the railway, it would be at least a surprise to find that there is in the United States a city entirely devoted to the making of luxurious palace cars—Pullman City, where over £40,000 a year are paid in wages to the men engaged in this one industry. At the end of 1884, the aggregate length of the railways of the world was 290,750 miles, the whole cost of which has been over £4,800,000,000.

Let us turn for a moment from the locomotive to the bicycle. In the early part of the century a very ponderous wheeled machine, called the hobby-horse, was introduced, which the rider bestrode and forced along by dabbing the ground alternately with either foot. This clumsy contrivance attracted the young men of fashion, however, and out of regard for them it came to be styled the dandy-horse. It was a German invention, and was brought into notice by a Baron von Brais and a Long Acre coachmaker named Johnson. It had its day, like other hobby-horses, and then passed out of sight. A modification of it was in use here and there some thirty years ago; but it was not until the modern inventor got to work amongst these machines and substituted iron for wood that anything really acceptable was produced. The bicycle and the tricycle are the outcome of these fresh experiments; and a steam bicycle is a recent invention.

It has only been possible to give a rapid glance over the vast extent of wheel-land, and indicate its leading features of development; but enough has been said to show its boundless wonders and romance.

CHAPTER XIX.

MACHINERY RIOTS.

The Leading Inventions of the Past—The Opposition they have Met with — The Luddites—Great Destruction of Machinery at Nottingham—Violence of the Agitation in the West Riding—Midnight Attack on Rawfolds Mill—Charlotte Brontë's Use of the Incident—Murder of Mr. Horsfall — Wholesale Executions — Further Outbreaks—The Plug Riots of 1842—Opposition to the Steam Printing Press—Mr. Walter's Vigorous Measures of Precaution –Sewing-machine Riots.

IN the early days of mechanical invention every new machine that restricted manual operations, or affected wide interests unfavourably, was the object of violent opposition. Nearly all the leading inventions up to within the last half century have literally had to be fought into popular acceptance.

The bow-men of the Middle Ages resisted the introduction of the musket; the old sedan-chairmen of Paris would not permit the employment of hackney carriages when they were first brought out; and the stage-coach proprietors would fain have blocked the passage of the locomotive, but it was too mighty a power for them to tackle conveniently. When, in 1707, Dr. Papin sent to England his first idea of a steamboat—his *petite machine d'un vaisseau à roues*—it was seized and destroyed by the boatmen at Münden, who imagined that, if successful, it would deprive them of their livelihood. Then there was great obstruction manifested towards the ribbon loom when it was originally made known, both in England and on the Continent. So violent was the feeling against it in Germany that the Imperial authorities were prevailed upon to prohibit ribbons through the whole of Germany, and the Council of Hamburg ordered a loom to be publicly burnt. The first prohibition took place in 1676, and it was not until the middle of the next century that the prohibitive decrees were withdrawn.

The stocking-loom, invented by Lee about the end of the sixteenth century, was kept back for many years by opposition; and nearly all the inventors of new machines for the cotton trade—Hargreaves, Kay, Arkwright, Crompton, and Cartwright—had to suffer from the attacks of workpeople who thought the machines would take their bread out of their mouths. Kay was mobbed, and had to escape from Lancashire when he attempted to introduce his fly-shuttle; Hargreaves had his spinning frame destroyed by a Blackburn mob; Crompton had to hide his great invention away in a lumber room for a year or two for fear of its meeting with a similar fate; Arkwright was denounced as the enemy of the working-classes when he introduced his new method of spinning, and a mill that he built near Chorley was entirely destroyed by a riotous mob; Jacquard narrowly escaped being thrown into the Rhône by a furious crowd of weavers when his new loom was first put into operation; Heathcoat, the inventor of the bobbin-frame for lace-making, had his factory and machinery destroyed in 1816, by a body of rioters, who set fire to the place with torches in the open day; and Dr. Cartwright had to abandon his power-loom for many years because of the bitter animosity of the people towards it.

The most serious outbreak of machinery rioters occurred in the early part of the present century.

This was the period when some of the chief labour-saving machines were being introduced in the factories of this country, and the working population were seized with the sudden impulse of destruction. The long and costly war which England had waged, and was still waging, with Napoleon, had reduced the people to the verge of starvation. Heavy taxation, dearness of provisions, and scarcity of employment, had crushed the hope out of the hearts of the labouring classes, and they were ready to wreak their resentment upon almost any object that presented itself. They watched with strong discontent the increasing power of machinery, which seemed to threaten them with extinction, and at last, unable to bear the prospect any longer, they began to plot and conspire to prevent any further encroachment upon their imagined rights.

It was in Nottingham that the first manifestation of violence was displayed, the stocking-weavers of the ancient town rising in determined opposition to the new loom, which was then being largely introduced. Riots were organised, under the leadership of a mysterious but not altogether mythical personage called General Lud, and attacks were made upon the various factories in which the obnoxious frames had been adopted. Over a thousand looms were destroyed in Nottingham. So desperate were the rioters that they quickly spread themselves over the whole of the manufacturing districts of the North, and wherever they went carried destruction with them.

Nowhere did the agitation bear more bitter fruit than in the West Riding of Yorkshire, where it spread with relentless force. The rioters used to assemble by night on the moors and commons, and there determine their plans of attack. They administered a fearful oath to all who joined them, each member being sworn never to reveal "to any person or persons under the canopy of heaven" the names of those who composed the secret committee, "their proceedings, meetings, places of abode, dress, features, connections, or anything else that might lead to a discovery of the same, either by word, or deed, or sign, under the penalty of being sent out of the world by the first brother," who should meet him, and having his name and character "blotted out of existence, and never to be remembered but with contempt and abhorrence."

The movement almost swelled to the proportions of a rebellion. As time wore on the boldness of the rioters increased; no mill was safe from attack, no mill-owner but felt his life in peril, for they not only pronounced the doom of the machinery, but of all who used it. Thousands of pounds' worth of property was destroyed in the cloth-weaving districts around Leeds, Dewsbury, and Huddersfield. Vigorous measures were adopted by the local authorities to put down the rioters, but for a long time their efforts were of little avail. Mr. Joseph Radcliffe, of Milne Bridge, was one of the most active of the Yorkshire magistracy in organising a system for the surprise and detection of the ringleaders, and he was bravely aided by the Rev. Hammond Robertson, of Hartshead (the Mr. Helstone of Charlotte Brontë's "Shirley"). For his services in this cause Mr. Radcliffe had a baronetcy conferred upon him. The assistance of the military had to be sought in many instances, and conflict between the soldiers and the rioters was frequent. Deeds of murder, atrocity, and outrage were committed on all sides, and the Government were compelled to pass a special Act of Parliament with a view to checking these crimes. Arrests were made daily, and the prisoners became so numerous that special commissions for their trial were opened in the various assize towns of the North. Rewards were offered and King's pardons to accomplices; but, though many offenders were brought to justice, the agitation did not abate. A crisis was precipitated, however, in the month of April, 1812, by the perpetration of two crimes of startling violence.

On the night of Saturday, the 11th of April, according to a preconcerted plan, a body of Luddites some hundred and fifty strong made an attack upon the mill of Mr. William Cartwright, at Rawfolds, near Liversedge. For more than six weeks previous to this night, Mr. Cartwright, four workmen, and five soldiers, had slept in the factory. The millowner knew that the Luddites were bent upon destroying his machinery, and he had determined, if possible, to prevent them. Shortly after midnight this gallant little band of defenders retired to rest, Mr. Cartwright having first assured himself that the pickets outside were at their posts. For a while all was as still as death; the first hour of the Sabbath had been entered upon with a calm peacefulness that was in harmony with the associations of the day. But the stillness was not to be of long duration. At twenty-five minutes to one, the dog in the yard began to bark furiously, and Mr. Cartwright immediately jumped out of bed. As he opened the door of the room where he had been lying down, he was startled by a crash of breaking windows and a discharge of firearms. He also heard a loud hammering at the mill doors, and the sound of many voices. He rushed to the spot where he and his companions had piled their arms before going to bed; the workmen and the soldiers were running to the same place; and all, like himself, were without clothing, except their shirts. There was no time to be lost. Each man seized his gun. Two of the workmen ran to the top of the mill and rang the bell. Then the bell rope broke, and they rushed down again. All this time the mob without were discharging their guns and pistols at the windows, and the hammering at the door was kept up unceasingly. George Mellor, the General Lud of the district, was leading the attack, the rioters having advanced in regular military order, the musket-men first, then the pistol-men, then the hatchet-men, club-men, and staff-men, those without weapons bringing up the rear. "Bang away, my lads!" "In with you!" "Kill them every one!" were the shouts that proceeded from the mob, as volley after volley was fired. But the half score besieged men were not to be so easily overcome. The conflict was kept up for about twenty minutes, and then, unable to effect an entrance, and having spent all their ammunition, the Luddites, repulsed and furious, retreated in the direction of Huddersfield, leaving behind them two wounded companions, who afterwards died.

This was the incident which Charlotte Brontë worked up with dramatic effect in "Shirley," only, for the sake of picturesqueness, she described the little mill in the hollow near Haworth instead of the one at Rawfolds. Mrs. Gaskell, in a note upon this circumstance, mentions the fact that some of the rioters had threatened that if they did not succeed in forcing their way into the mill, they would break into the house, which was near, and murder Mr. Cartwright's wife and children. "This was a terrible threat," she wrote, "for he had been obliged to leave his family with only one or two soldiers to defend them. Mrs. Cartwright knew what they had threatened; and on that dreadful night, hearing, as she thought, steps approaching, she snatched up her two infant children and put them in a basket up the great chimney, common in old-fashioned Yorkshire houses." Within a week of the attack on the mill, Mr. Cartwright was twice shot at on the high road. The ringleaders were subsequently arrested and tried at York. Mr. Cartwright was presented with a sum of £3,000, subscribed by neighbouring mill-owners, as a tribute of admiration of his courageous conduct.

A few days after the attack on Rawfolds mill, Mr. William Horsfall, a manufacturer at Marsden, while riding home from the Huddersfield market, was fired at from behind a wall and killed. Four Luddites—George Mellor, William Thorpe, Thomas Smith, and Benjamin Walker—were concerned in the commission of this crime. Walker afterwards turned King's evidence, and the other three were hanged. At the special commission opened at York in January, 1813, sixty-four persons were put upon their trial for offences connected with Luddism, and fifteen of them were executed on the same scaffold on the morning of the 16th of January. This severe example had the effect of repressing the agitation.

The introduction of the power-loom into the textile industries of the North, during the second quarter of the century, gave rise to what were known as the Plug Riots, so called from the fact that the rioters at all the mills attacked forced in the plugs of the steam boilers, by which means the machinery was stopped. This was not such a serious matter as the wholesale destruction of mills and machinery which the Luddites had indulged in; still it was the cause of much inconvenience, and for a considerable period kept the manufacturing districts in a terrorised condition. These outbreaks had been threatening for some time. In 1822 a power-loom which had been secretly erected in a small mill at Shipley was got at by a party of rioters and destroyed. In May, 1826, a still more serious disturbance took place at Bradford, at which place Messrs. Horsfall, a firm of worsted manufacturers, had put several of the new power-looms into operation. An angry mob assembled and made a desperate attempt to force their way into the building, but they were met by a small protecting force which had been for some time on guard inside, and were prevented from entering. The windows were assailed with stones by the rioters, and one of them sent a shot whizzing after the missiles. This had the effect of alarming the defenders, who at once replied by firing twenty or thirty shots into the crowd, killing two persons and wounding a large number. After that the rioters dispersed, and for a time no further opposition was made to the introduction of power-looms in that locality.

In the year 1842, by which time the power-loom had become thoroughly established in the North, the factory workers were in a condition of great distress. Industrial stagnation prevailed everywhere, and, as before, the depression was attributed to the introduction of machinery. It was then that the unemployed banded themselves together in riotous combinations, and through all the manufacturing districts of the North great mobs of plug-drawers sped from town to town, and village to village, hardly a mill escaping their attacks. The agitation threatened at one time to assume the seriousness of the Luddite disturbances, but the people had not yet recovered from the terror which had been left behind by the exemplary punishments dealt out to the chief offenders in 1813. Moreover, the authorities now acted with greater vigilance, confronting the rioters at every point, so, after a few months of disquiet, the agitation spent its force without leaving in its wake anything like the memories of crime and bloodshed which had remained from the Luddite movement. When, later on, other important labour-saving machines came to be introduced into the textile manufactures, they were permitted to be worked in peace, for by this time the economics of supply and demand had begun to teach their lesson of adjustment, and it was seen that it was useless, as well as suicidal, to attempt to stem the tide of mechanical progress. Not even when the combing-machine was brought into operation—by which was abolished at a stroke a manual industry which had existed almost from the beginning of trade, employing many thousands of persons—did the sufferers rise in resentment, but quietly betook themselves, as best they could, to other occupations—in many instances to other countries—and as combers were heard of no more.

Something very near a riot was the result of the introduction of the steam printing press, but was prevented by the admirable firmness of Mr. Walter. The pressmen had threatened both the inventor and his machine, and Mr. Walter knew there was danger in their attitude. Dr. Smiles gives the following graphic account of the way in which the proprietor of the *Times* overcame the opposition:—

"At length the day arrived when the first newspaper steam press was ready for use. The pressmen were in a state of great excitement, for they knew by rumour that the machine of which they had so long been apprehensive was fast approaching completion. One night they were told to wait in the press-room, as important news was expected from abroad. At six o'clock in the morning of the 29th November, 1814, Mr. Walter, who had been watching the working of the machine all through the night, suddenly appeared among the pressmen and announced that 'the *Times* is already printed by steam!' Knowing that the pressmen had vowed vengeance against the inventor and his invention, and that they had threatened 'destruction to him and his traps,' he informed them that, if they attempted violence, there was a force ready to suppress it; but that if they were peaceable, their wages should be continued to every one of them until they could obtain similar employment. This proved satisfactory so far, and he proceeded to distribute several copies of the newspaper amongst them —the first newspaper printed by steam!" After that there was no disturbance or destruction.

Perhaps, the last riots in connection with inventions were those which occurred in America on the introduction of Howe's sewing machines; but they were, fortunately, not attended by any serious destruction of property, nor did they keep back the invention from general adoption.

CHAPTER XX.

INVENTORS ON THE BATTLE-FIELD.

Early Weapons—The Bow and Arrow — Pharaoh's Hosts—Bronze and Copper Weapons of the Homeric Age—The Introduction of Iron Arms — Harold's Infantry—The Military Age of Feudalism — The Birth, Growth, and Decline of Armour—Invention of Portable Fire-arms—The Last Arrow — Franklin Advocates the Return to Bows and Arrows—Clumsiness of the Early Muskets—Gradual Improvement in the Fire-arm—Introduction of Breech-loading Arms—Early Artillery — Charles I.'s *Bouches à Feu* — Rifled Cannon — Sir Wm. Armstrong Tempted into the Battle-field—The Battle of the Guns—The World's Cannon.

THE art of fighting has been one in which inventors and men of science have struggled for supremacy quite as fiercely as the soldiers who have used their weapons have fought for actual victory on the field. Since the first men who quarrelled knocked each other down with their fists, and a burning animosity made them eager for means of offence and defence of greater force than the weapons with which Nature had supplied them, the inventor has been pressed into the service of fighting men, and, well paid and well aided, has produced a succession of weapons of ever-increasing power, until now it is the inventor rather than the soldier who fights the battles of nations.

Sticks and stones were the first weapons with which man armed himself, and from these by a natural gradation sprang clubs, hatchets, axes, slings, and spears. Knives and daggers also were made of stone, before the discovery of metals. Later on there came the invention of the bow and arrow, which served mankind for thousands of years as the chief weapons of warfare. All the ancient civilised races were archers. Hagar had her son Ishmael trained to the use of the bow, after her expulsion by Abraham, and as an archer he distinguished himself. The bowmen, the slingers, and the spearmen of the armies of Pharaoh formed a mighty host of warriors, with their attendant chariots and horsemen ; and the pictorial records and written chronicles of the past exhibit innumerable evidences of the use of these primitive weapons.

Weapons of bronze and copper were in use in the Homeric age, and these were succeeded some hundreds of years afterwards by iron weapons ; but it was not until after the second Punic war that the Romans began to use iron in the fabrication of arms. Gradually the weapons of Rome, as well as those of northern nations, crept into use in England, and before the time of the Norman Conquest the Anglo-Saxons were almost as well furnished with implements of warfare as their contemporaries. So attached was the Saxon freeman to his arms that he would invariably order them to be laid beside him in his grave when he died. The only defensive armour worn at that period was the helmet, the spear being the principal weapon of attack. When Harold led his forces to battle, his chief strength was his infantry, the cavalry being but a small force consisting of thanes, or such as were able to provide a horse at their own cost. Drawn up in order of battle, the wielders of the battle-axes formed an almost impenetrable phalanx, with their joined shields in front of them ; but great changes followed the defeat at Hastings, when the spirit and picturesqueness of Norman chivalry succeeded the rugged vigour of the Saxon soldiery. Defensive attire now made its way slowly into fashion, and corresponding changes were made in the nature of weapons.

Europe now fell upon a time of romance, and war, and chivalry. The feudal system, with its jousts and tournaments, its din of Paynim battle and its alarms of personal combat, spread itself over all the nations of the West. An era so exclusively military in its character had not existed since the Homeric age. Now the body armour of the soldier was composed of metal rings and scales, stitched on leather or cloth. From this they got to coats of chain and scale mail; and then into coverings for the entire body. So they went on, increasing the strength and weight of the armour until they could not carry any more. To the mail armour they added detached plates of iron or steel; then gradually these plates were extended to other parts, and ultimately superseded the mail armour entirely, the warrior becoming encased in steel from head to heel. With this cumbersome load the knight continued to go to battle, until the "villainous saltpetre" was "digg'd out of the bowels of the harmless earth" for the making of gunpowder, and the heavy sheathing of steel became useless against the might of the firearms with which the inventor now made his first important appearance on the battle-field. In the same gradual way that armour had reached its culminating point of strength it now came to be discarded, piece by piece, until the steel gave way to leather, and leather to buff, and the soldier was left with nothing but his own bravery and skill between him and the murderous bullets of the new weapon of fire. Armour was not relinquished without regret, however, nor was the musket permitted to be introduced without violent opposition.

Peace-loving James I. remarked that he could not but greatly praise armour, as it not only protected the wearer, but also prevented him from injuring any other person. It was the gallant Bayard who said, "It is humiliating that a man with a heart in him should be exposed to destruction by a wretched gun;" and Montluc wished to God "that that accursed instrument [the arquebus] had never been invented," adding that but for it he would "not now bear the marks of it, and many brave and valiant men would not have been killed, by cowards who would not dare look in the face of him whom they stretch on the ground with their wretched bullets."

The long bow had been introduced to this country by the Normans, but it was readily taken up by the native population, and used with splendid skill and effect in the battles of Creçy, Poictiers, and Agincourt. The English archer became an unerring marksman, and to his steadiness of eye and muscular arm many a victory was due. The arms of knighthood were the lance and the sword; still, the battle-axe, which had been such a powerful weapon in the hands of the Anglo-Saxon, kept its place, and under the favour of Richard I. again became the chief weapon of attack for persons of estate. Cœur-de-Lion himself was greatly enamoured of this deadly instrument, and used it with terrible power upon his enemies. The martel and the maule were also amongst the offensive arms of chivalry. The latter was a ponderous steel mallet, blunt at both ends; the former was sharpened to a point, and was a most formidable weapon, giving its name to Charles Martel, the grandfather of Charlemagne, who was an adept in its use. Then there was the mace, which consisted of a heavy iron ball attached by chains to stout staves.

But all these murderous weapons were rendered comparatively useless by the introduction of the new firearm. According to Meyrick, portable firearms were invented by the Italians about 1430. "This invention," we are told, "in its primitive state was one of extreme simplicity, consisting merely of a tube fixed to a straight stock of wood, furnished with trunnions, cascable, and touchhole, in the first instance at the top, like a large cannon, but afterwards altered to the side, where a small pan was placed to hold the priming, and lessen the liability of its being blown away by the wind."

It was not until some hundred years later that the musket took its place amongst the arms of England. The bow had been of such good service, and was so interwoven with the romance and valour of the past, that the people clung to it with sentiments of affection long after the more deadly instrument had been adopted. Queen Elizabeth was more partial to her archers than to any other portion of her army, although there was that famous "pocket-pistol" of hers, the sixty-pounder at Dover Castle, which was considered a rather big thing in its time. Favourite long bows were bequeathed from father to son as precious heir-looms, and even now the walls of many an old house display one of these relics of the past, which contrast so strangely with our later weapons of war. There is a tradition that guns were first introduced into battle at Creçy, but there is more than tradition to show that the bow was used in actual warfare in England so late as the time of the Civil War. The last bowman's battle-shot fired in this country is supposed to have been discharged at the siege of Devizes, under Cromwell and Fairfax. A bearded arrow hurtled through the air, fired by some bowman in the town, at Sir Jacob Astley as he stood by the river side. The arrow stuck in the ground between the knight's legs, and as he stooped to pick it up he said, "You rogue, you missed your aim." That was the last bow-shot in English warfare, but it was by no means the last arrow that British soldiers would have to face; both the long and the cross bow were used against the Enfield rifle by the Chinese in the last war which England waged with the Celestials. Benjamin Franklin advocated the return to bows and arrows at the time of the war of Independence. The philosopher and inventor maintained they were good weapons which were not wisely laid aside, because, firstly, a man might shoot as truly with a bow as with a common musket; secondly, because he could discharge four arrows in the time of charging and discharging one bullet; thirdly, because his object was not obscured from his view by the smoke of his own comrades; fourthly, because a flight of arrows seen coming upon them terrifies and disturbs the enemy's attention to his business; and sixthly, because bows and arrows are more easily provided everywhere than muskets and ammunition.

There was, it must be confessed, much to be said against the musket as well as for it. If it was more destructive than the bow, it was also more unwieldy and more difficult to manage. The firearm was so heavy that the soldier could not raise it in his arms to fire it, but had to rest it on a "fork" that stuck in the ground, before he could bring it to bear upon the foe; and there was so much time lost in preparations for firing, that the "rest" had to be armed with a spike, either projecting from one prong, or thrown out from the staff by a spring in the form of what were called "Swedish Feathers," as a protection for the soldier against attack during the process of loading and preparing. This musket was a ponderous machine in its infancy. It could only be wielded by a strong man, and the carrying of the "rest" was a duty that had often to be performed by an attendant. Then there was the match to be looked after, which consisted of a piece of loose hemp, with the top in a continuous smoulder, and was sometimes carried in a tin tube, but more often in the pocket or inside the hat. Add to this, the ammunition, which was comprised in a dozen charges of powder enclosed in a dozen boxes, suspended to the shoulder belt, and the leathern bag for holding the bullets, and we get some faint idea of the load which the early musketeer had to bear with him to the field of battle.

The inventor came to the rescue, and soon altered this state of things. All through the sixteenth century his brain was at work devising improvements in firearms. A German inventor introduced the bent gunstock; then the pyrites wheel-lock was brought out; which was followed by the snaphance or fire-lock, claimed by Grose as a Dutch invention. The flint-lock continued to be in use until a comparatively recent date, but it has been left to our own time to lift the firearm out of its primitiveness and set it on its present footing as an efficient instrument. Great as were the improvements invented from the time of the original arquebus down to the period of the English Brown Bess, which had to do all the heavy fighting against Napoleon, it was not until the breech-loading rifle was introduced that the hand-gun became of any real utility for aiming purposes. The old musketeer shot in the direction of the enemy, and that was about all he could say with any degree of certainty; if his bullet found its billet, well and good, he had no means of ascertaining whether it did or not. In those good old times it is said that each man fired away his own weight in lead for every man that he hit. A Scottish clergyman, the Rev. W. Forsyth, of Belhelvie, in Aberdeenshire, is credited with the invention of the percussion cap, which greatly simplified the firing process; and some quarter of a century ago the breech-loading principle was introduced into portable firearms, and the increase of precision and destructive power which resulted from this production of many inventors was very great.

In 1864 a Committee was appointed to inquire into the question of improved arms for our infantry, and an attempt was made to put England on an equal footing with other nations in the matter of breech-loading arms. Sweden, curious to say, had invented a breech-loading rifle a full quarter of a century before this time, and the needle-gun of Prussia had been long in use, as also had the new French musket, which, with its "cylindro-conical-hollow-expansive-ball," was capable of dealing out destruction at the rate of six shots a minute, with a range of 1,500 yards. The inventors were now at work in real earnest, fighting their scientific battles on behalf of their respective countries. The Committee of 1864 recommended a sort of compromise between the old style and the new, the result of which was that for a time the old muzzle-loader was altered to a breech-loader, the gun-maker Snider having invented a method of conversion which, at a small cost, sufficed for temporary requirements. In 1866 the Government instituted a competition amongst rifle inventors, and no fewer than 104 different weapons were submitted, nine of which were adjudged worthy of serious consideration. The expectations of the Committee were scarcely realised for all that, inasmuch as it was decided not to award a first prize to any of the competitors. Mr. Henry received the second prize; and there was something in the invention of Mr. Martini, to whom the seventh prize had been awarded, which afforded valuable suggestions; so, instead of adopting any one of the rifles, it was ultimately decided to combine the inventions of Mr. Henry and Mr. Martini, and the result was the Martini-Henry rifle, which supplied the British army with a new small arm of equal efficacy to the breech-loading small arms of Continental nations. But the battle of invention still proceeds, fabulous sums are being spent every year in experiments, and although the Martini-Henry may one day be the favourite rifle in England, the Minié or the Chassepot in France, the needle-gun in Germany, these will in all likelihood be superseded in their turn by other inventions; for while the prizes to be won in this field of competition continue to be so great there is no likelihood of any diminution of effort.

But while inventors have been busy with arms for the infantry services, they have been more active still in the production of the heavier ordnance of artillery. We have to go far back in history of arms to get at the first cannon. The first instance of the use of the cannon by the English is said to have occurred at the battle of Were Water, in 1327, when Bruce fought with the British foe. Previous to that time, the larger machinery of war had not travelled far beyond the catapults hurling heavy stones and the balistæ discharging ponderous darts with which the hosts of Pyrrhus went into the field against the Romans. Indeed, it is not until we get far into the present century that we find any really heavy pieces of ordnance. Guns of bronze were cast in France and Germany about 1370, and from that period until the close of the fifteenth century, this material gradually replaced wrought iron, of which guns were in the first instance constructed. Mons Meg, of Scotland, and the great gun of Ghent, as it was called, would appear of immense magnitude and strength to people who had hardly cast aside their bows and arrows. Charles the First, with his *bouches à feu*, firing away at the Puritan enemy within the town of Coventry, was able to do so little damage that he sent to Nottingham for a couple of petards; but the faithful Rupert and Digby turned over their stores in vain to find anything of the kind, so Colonel Legge, being a man of resource, got hold of a couple of apothecaries' mortars, bored a touch-hole in each and sent them to the king, who was able to blaze away with these improvised cannon much better than he had been able to do with his *bouches à feu*. This was pretty much the condition of artillery affairs all round. Progress was being made, but very slowly, and it was not until the latter part of the eighteenth century that these dread engines of war began to assume anything like Titanic proportions. Inventors had not got fairly to work on the battle-field as yet. About 1660, cast-iron was first used for the material of cannon. Luttrell, in his Diary, under date of 8th January, 1689-

90, mentions that preparations are being vigorously pushed forward for an expedition to Ireland, and that "four of the new invented wheel engines, which discharge 150 musket barrels at once, and, turning the wheel, as many more," are to accompany the army. In Roberts's "Life of Monmouth" there is also mention made of a machine, bearing date 1678, in the Arsenal at Vienna, by which "fifty muskets could be discharged in any direction, and at any angle, by the application of a single match." These are clearly the prototypes of our present-day Gatlings, mitrailleurs, and other machine guns, but they do not come under the designation of heavy ordnance.

It was reserved for our own time to introduce heavy guns and rifled artillery. The latter plan, however, is by no means so recent as is popularly supposed. Early in the last century the notion of rifled cannon had been broached in Germany, and in 1745 an Englishman named Robins, the inventor of the ballistic pendulum, had tried his hand at it. Pouchard, at Paris, in 1819; Montigny, at Brussels and St. Petersburg, in 1836; and, more recently, Colonel Cavalli, in Sardinia, and Baron Wahrendorf, in Sweden, had experimented on similar lines, but without obtaining any practical result. Not only had the idea to be thought out more thoroughly, but, as in the case of most other inventions of importance, the barriers of prejudice had to be broken down, which is always a slow process. Between 1840 and 1852, Colonel Treuille de Beaulieu worked steadily away at the rifled cannon problem, and when Louis Napoleon entered into possession of place, power, and empire, he took this matter up, having himself, while in the dungeon of Ham, written a book on artillery. The

Emperor found an opportunity of encouraging and assisting in experiments in connection with rifled cannon; and in 1856, when France went through her Italian campaign, these new engines of war were for the first time employed in actual battle, and with such effect as set Europe thinking. After the battles of Magenta and Solferino had been lost and won, to use the words of Sir Emerson Tennent, the signal was given "for the reconstruction of all the artillery of Europe." There was now a rush of inventors to all the Governments of the civilised world, and the Governments, for once, did not object to be approached by the inventors. Amongst these men of invention were Lancaster, Bashley Britten, Treadwell, Captain Blakeley, Horsfall, Whitworth, and Armstrong. It would be beyond our purpose to set forth in these pages how much each of these gentlemen accomplished towards the revolutionising of heavy ordnance and the introduction of rifled cannon; all we can do is to state a few general results.

The way in which Sir William Armstrong was first drawn to consider this subject is deserving of mention. His history has a good deal of the romance of invention in it. To begin with, he was a lawyer, with a turn for inventive experiment and an intense love of angling. One day, while enjoying the pastoral delights of fishing in a quiet northern stream near which a mill wheel ran, he observed a contrivance for raising water which to him seemed a sheer waste of power, and set him thinking how this waste could best be obviated. From that idea he evolved a series of hydraulic machines which completely changed the course of hydrostatics. The hydraulic crane was the first practical outcome of his new turn of thought, and his success with this machine caused him to bid farewell to musty parchments and legal hair-splittings for ever. He was a maker of hydraulic machinery in a prosperous way of business at Newcastle at the time of the Crimean war, and might have continued a maker of hydraulic machinery to the end of his days had not his inventive mind caught at a new idea, altogether away from his own sphere of operations, by reading an account of the battle of Inkermann. He read that this victory was largely owing to the bringing up of two 18-pounder guns, which, by their superior range, effectually silenced the Russian fire.

"Sir W. Armstrong," says Sir Emerson Tennent, "was amongst those who perceived that another such emergency could only be met by imparting to field guns the accuracy and range of the rifle; and that the impediment of weight must be removed by substituting forged instead of cast iron guns." Acting upon this idea, Sir William prepared a design of such a gun as he thought would meet the difficulty, and in 1854 waited upon the Duke of Newcastle, the then Secretary for War, and submitted it to him, with the result that he was commissioned to construct a breach-loading cannon on the plan proposed. The inventor lost no time in working out his scheme, and after many months of patient labour and experiment, succeeded in constructing a gun which met the approval of the War Office, and instituted a new era in gunnery. When this new piece of ordnance was adopted it was said of it that it could "hit a target 2 feet 6 inches in diameter, while the old service gun could not be relied upon to hit a haystack;" and General Peel asserted in the House of Commons that "at equal distances the

Armstrong gun was fifty-seven times as accurate as our ordinary artillery." Since then the battle of the guns has been carried on with ever-increasing activity, and Sir Joseph Whitworth, Major Palliser, Mr. Fraser, Mr. Anderson, and others, have effected improvements of various kinds, until now steel has been substituted for wrought iron, and from the 3-pounder which Sir William Armstrong started with, we get to monster pieces of 100 tons; and guns are constructed at costs of thousands of pounds each, to be superseded by other guns of still greater cost, the work of invention never resting; for such is the condition of military armament in these days, that no great Power can afford to fall behind in the race, whether there be war or not. The greatest prizes are to be won in this field of invention, both in England and in other countries. Krupp's ordnance works at Essen, in Prussia, are the largest works in the world, giving employment to upwards of 10,000 men. Along with the improvement in guns, there has been a corresponding improvement in projectiles, which have been entirely changed both in shape and substance.

Some idea of the marvellous achievements of the inventor on the battle-field—or, rather, in preparing for the battle-field—may be formed by a brief reference to recent statistics on the subject. There are said to be at the present time about 37,000 pieces of cannon in existence in the world, 7,572 of which belong to France, 5,380 to Germany, 5,124 to Russia, 4,182 to Great Britain, 4,155 to the United States, 2,800 to Austria, 1,480 to Italy, the remainder being distributed amongst minor nations, Belgium bringing up the rear with 244. The cost of guns per ton has been greatly increased since the days when the strength of the

British artillery force was represented by the firing of 9,467 rounds of shot at the battle of Waterloo. The cost of cast iron ordnance was £21 per ton; the steel guns of Krupp cost £170 per ton.

Shells and explosive bullets have also engaged the attention of the inventor to a very great extent of late years. There are shells weighing 700 lbs., and mortars capable of ejecting a weight of 2,986 lbs. a distance of a mile and a half. The shrapnel shell consists of an iron case enclosing a number of bullets which, on exploding, spread out in all directions. The segment shell is filled with pieces of cast iron instead of bullets. A military authority states that "the 7-in. shrapnel contains 227 bullets and a 9-in. shrapnel would contain 500 bullets of the same size, and these shells could be burst with extraordinary accuracy upon objects 5,000, 6,000, or 7,000 yards off."

Of the invention of gun-cotton and nitro-glycerine, which have proved to be such powerful agents of destruction, a great deal might be said; but as these things are so much of the present time it is, perhaps, needless to go into detail. Millions of pounds are spent on war machinery which becomes obsolete before it can be got into operation; but the inventor must keep pace with the times in this field of activity, no matter what the cost. If ever the day comes when there shall be another great war in Europe and all these dread inventions shall be sent forth to show their power, the work of carnage will be more terrible than it has ever been before. The inventor on the battlefield has at command all the forces of Nature, and assumes the *rôle* of the demon of destruction to horrible purpose.

CHAPTER XXI.

KINGS OF THE KITCHEN.

Cooks as Inventors—Mark Antony's Cook—The Pleasures of the Table in Ancient Rome—The Annals of Gluttony—The "Second Hunger"—Beginnings of Cookery—The "Flesh-pots of Egypt"—Ancient Greece and its Culinary Artists—Black Broth of Sparta—The Hellenic Cook in Rome—Scarcity of Table Implements—Cookery of the Middle Ages—Greasy Cookery of the East—The Monastic System and its Cookery—The Artist-inventor Cook of the Seventeenth Century—Well-fed Britons—England and her Sauces—A Fortune out of Stale Crusts—Culinary Novelties—The Era of Tinned Meats—Demand for "Dinner out of Nothing."

THERE are inventors and inventors, and not the least important of the race is he who descends into the magic realm of the kitchen, not with revolutionary ideas on the subject of pots and pans, ovens and ranges; but with his mind intent upon the evolvement of some new pleasure for the palate. The inventor of the kitchen is the cook, whose influence is of wider extent, perhaps, than that of any other inventor, for while other projectors only bring a section of their fellow-creatures within the scope of their operations, the king of the kitchen has the whole of humankind under his sway. True, he is not able, as a rule, to bring his inventions under the protecting wing of the Patent Laws, but he has the priceless consolation of knowing that his skill can charm the mightiest no less than the lowliest. Not that the world is altogether ungrateful to its cooks; they have their rewards occasionally, like other inventors, though probably not to the same extent in modern times as in those days of old when epicureanism was the prevailing passion of the great and the powerful. Ude, Soyer, Gouffé, Carême, Vatel, Francatelli, and even honest Mrs. Glasse—who, by the way, never did say you were first to catch your hare—received honour and emolument of a not despicable kind; still no cook of these times has obtained recognition equal to that which Mark Antony accorded to the cook who prepared such a beautiful repast for Cleopatra that the Roman general presented the *maître de cuisine* with a whole town.

The ancient Romans believed in the pleasures of the table and paid for them generously. Apicius was a martyr to his stomach—not a sufferer from indigestion, but rather the reverse—for when he had spent nearly 60,000,000 sestertii on his palate and then discovered that he had only 10,000,000 sestertii left to stave off hunger and privation, he retired to the solitude of his chamber and hanged himself. Vitellius allowed his cook £3,000 a day for marketing purposes; and Lucullus once paid £1,000 for a little dinner for three—himself, Cæsar, and Pompey. Heliogabalus was so prodigal in his expenditure upon his table that he had his peas sprinkled with grains of gold, his rice mixed with pearls, and his beans blended with the costliest amber. Tiberias had precious stones crushed and mixed in wine, as also had Cleopatra. The Romans gave themselves up so completely to the sensual extravagance of eating and drinking that the annals of the Empire have been not inaptly described as the annals of gluttony. Day after day the cook was called upon to invent fresh messes; the farthest ends of the earth were ransacked for new delicacies; and the plunder of a province was often represented in a single meal.

What times those must have been for the cook! How he would be able to enrich himself! When invention failed him, however,—when his resources were exhausted—immense rewards were offered for the discovery of new combinations of food to stimulate the cloyed appetites of the imperial epicures and their parasites. The livers and tongues of nightingales, rhinoceros' eyes, the tender parts of peacocks, and the brains of pheasants, flamingoes, and thrushes were amongst the ordinary items of the Roman *menu*. Æsop, the actor, used to regale on the tongues of such birds as possessed the faculty of imitating the human voice; and Pollio used to fatten his lampreys upon human flesh, in order to give them a more exquisite flavour. The Romans nursed their palates to such an extent that the "second hunger," which Juvenal sings of, was cultivated as a science, and Apicius himself, the chief gastronomer of his time, delivered lectures on the various modes of exciting the palate, established a "school of gluttony," and left behind him, as a legacy to his country, no fewer than ten books of receipts.

The Roman cook of imperial days was not an inventor in the true sense of the word; the cook inventor makes much out of little, not little out of much; and the cooks who administered to the stomachic cravings of such gross sensualists as Vitellius, Nero, Commodus, Heliogabalus, and Apicius, had to concern themselves mainly with the provision of rarities, which, with the imperial purse always open to their hand, was no very difficult matter. The older civilisations had been more refined in their feastings. Nowhere in history do we read of such animal indulgences as those of the Romans of the "decline and fall."

The beginnings of cookery are necessarily shrouded in mystery, although there is little doubt cookery would be the beginning of invention. The Bible is not very explicit on this subject. It has been said that Adam was created in autumn, when all the fruits were ripe, so that there was no immediate necessity for him and mother Eve to commence culinary operations until they had acquired some knowledge of the newly inhabited earth and its multifarious products. This idea may, or may not, be borne out by the allusion to the fruit of the garden of Eden ; but it may serve as a not unpleasing fancy.

The Old Testament does not help the student of early cookery very much. The learned Rabbi, El Bassam, is said to have spent fifteen years in vainly trying to discover the name of the cook who made the pottage for Esau. It seems a pity that such thoroughness of research should have been unrewarded. When the Israelites were in Egypt they found an advanced knowledge of cookery existing in the land of Pharaoh, and after their escape from bondage, during their privations in the wilderness, indulged many longings for the "flesh-pots of Egypt." And when we read that "the butler of the king of Egypt, and his baker, had offended their lord," we may be sure that it was for some shortcoming of theirs in connection with one of the king's banquets. On the tomb of Rameses III., at Thebes, is a painting depicting the interior of an Egyptian kitchen, in which cooks are represented in the operations of roasting, boiling, basting, skimming the pot, blowing the fire, pounding spices in a mortar, and performing other duties of their calling in much the same manner as these things are done at the present day. There is an Egyptian painting in the British Museum which represents a shoulder of veal, and a goose, plucked and trussed, ready for the spit. Amongst the Assyrians, the Babylonians, and the Persians, we know that feasts of great splendour were frequently given by the powerful monarchs of those countries, but what the special viands were at Belshazzar's feast, or at the orgies of Sardanapalus, we have no means of learning.

The culinary artist gleams through the mists of Grecian fable. Cadmus, the grandfather of Bacchus, we are told, was a Phœnician cook, who, having left the service of the King of Sidon, went over to Thebes in Bœotia, and taught the Hellenic tribes the mysteries of cooking. The divinities of Olympus, though, were more famous for the quantities than the qualities of food they consumed. Hercules could eat a whole ox at a sitting, and at the banquet of the Centaurs and Lapithæ he returned the pledge of Pholus in a goblet containing forty-eight gallons of red wine. Aristæus, son of Apollo, invented cheese; and the Delians were the first to practise the art of cramming fowls. The works of Homer, Pindar, Aristophanes, and Socrates abound with gastronomical references. The heroes of the Iliad were mostly generous patrons of the culinary arts. Achilles used to have a dish of lion's marrow prepared for him by the Centaur. The Spartans brought their more than stoical severity to bear upon the inventive art of the kitchen when they prescribed for themselves their famous black broth, of the ingredients of which we know nothing, though it has been contended that the modern Scotch haggis bears some resemblance to it. It is related that, on a certain occasion, a native of Sybaris had some of this black broth given to him, and that he expressed his opinion upon it in these words:—"I am not astonished that you Spartans are so fearless of death on the battle-field, since any one in his senses would rather die than be compelled to live on such execrable food."

In old Hellas the cook was generally a slave, but he did not glory any the less in his art for that. Many of the art-workers of Greece were slaves. The feast of the Greeks was a "feast of reason" tempered with a mild asceticism, not a mere gluttonous wallowing in savoury condiments, like that of the Romans. Plato, with his diet of dates and cold water; and Æneas, with his frugal biscuit, might represent one extreme, but the Hellenes would not go to the other; they were artists in eating and drinking, as well as in the plastic arts. Greece, it has been said, was the birthplace of the poet; and the same inventive force which of a block of white Paros marble could mould a woman, tall, queenly, most lovely and delicate, or a sun-god with unshorn hair and matchless limbs, motionless, yet on the threshold of life, it seemed, so perfect was the mockery—that same inventive force gave "law and order to the kitchen." Of their goat's flesh, beef, mutton, and pork they contrived, with the help of game and fowl, to make their *pièces de résistance*, while the lighter portions of their repasts were supplied from their rich stores of olives, lemons, figs, melons, pomegranates, pears, apples, and certain bulbous roots, regarding the precise nature of which there is some doubt. The Greek cook exercised his ingenuity upon rational things, and wrought wonders with such eatables and drinkables as came in his way in the natural course of his experience. He neither needed to send to Mesopotamia nor to India for costly delicacies ; his own country supplied him with all that his art needed. When, however, he fell upon evil times and evil people—when Greece had to acknowledge servitude to Rome, and the Hellenic cook had to transfer his talent to the imperial kitchens on the banks of the Tiber—he adapted himself to the necessities of the situation, and the demands of his employers, and spent their money for them as they desired it to be spent, in administering to their wasteful extravagance and gross sensuality. This was what the Greek cook became by his translation from Athens to Rome.

Invention had not up to that time done much in the way of supplying the festive boards of the great with table implements. Forks were unknown to the Greeks and Romans; indeed, these now indispensable instruments were not known until towards the end of the fifteenth century, when Italy seems to have had the honour of introducing them to civilisation. Amongst the ancient Greeks the sexes dined separately; but the Romans permitted women to eat with them, and provided them with seats, the men reclining on sofas. Table napkins appear to have been introduced by the Romans, but each guest was expected to bring his own. There was more wiping of fingers and throwing away of scraps, however, than would be considered pleasant nowadays.

The cook did not make much progress with his art during the Middle Ages. A spirit of semi-barbarism spread over the face of Europe, and the warlike races who fought "like devils for conciliation, and hated one another for the love of God," gave themselves but little concern with the pleasures of the table. It was a rough and ready time, and they were satisfied with a rough and ready cooking. Herculean capacities of digestion prevailed, and Herculean libations were indulged in; but with nothing more artistic to practise their skill upon than the roasting or stewing of gigantic masses of beef, and the preparation of beverages of unlimited quantity, it was hardly to be expected that the cook would trouble himself much with inventing new dishes. They were essentially coarse feeders in those days. They wanted their healthy hunger satisfied, not their palate tickled.

In the time of the Crusades, European knighthood became acquainted with the greasy cookery of the Orient, but they brought little of it home with them. Condiments swimming in onions and fat, and luscious mysteries stewing in unwholesome caldrons, were not likely to tempt the stronger-feeding races of the North. The East was the land of seasonings, hot and strong, rather than piquant and tickling; the North was the land of a plain living something akin to the carnivorous, of underdone meats and strong drinks. It is said that when the Caliph Abdalmelick entered Cufa as conqueror, and gave a splendid entertainment to the principal inhabitants by way of conciliation, he desired an elderly Mechzumian to tell him what food he liked best of all that he had ever eaten. "The head of an ass, well seasoned, and well roasted," was the reply. "You know nothing," cried the Caliph; "what say you to a shoulder of veal, well roasted, and covered with butter and milk?" This very dish is said to have been the one that Abraham presented to the angels on the plains of Mamre, and is to this day given to their more distinguished guests by the Arabs of Morocco. It is the same in all Oriental countries; the cook must disguise everything in savoury seasonings.

After a time the cook had a new opportunity afforded him of distinguishing himself, by the establishment of the monastic system, when bodies of pious men began to gather together in the peaceful valleys, praying for the souls of their countrymen and enjoying the good things of the earth as only men who are on good terms with the world, and have no onerous duties to perform, are capable of doing. The refectories of the monasteries and the kitchens of the ecclesiastics became the cook's strongholds. The tables of the monks of Canterbury consisted daily of sixteen covers of the most costly dainties. So great did the reputation of the pious fathers become, that the Lord Abbot was generally asked for the loan of his cook when any grand banquet had to be prepared. Then was the time of venison pasties, of roasted peacocks, of stewed geese, and other wondrous things of wholesome fare. They began to have splendid feasts, and the cook was encouraged to the top of his bent. Some of the earliest printed books deal with matters of cookery, showing the rapid strides the art was making under the monastic influence and example. Even so early as the time of Richard II. a vellum roll of cookery receipts was put forth by the master cooks of the king, by "assent and avysement of maisters of phisik and of philosophie." The purport of this document was thus explained: "First it techith a man fer to make commune pottages, and commune meetis fer howsold as they shold be made, craftly and holsomly. Aftirward it techith fer to make curious potages, and meetes, and sotiltees for alle maner of states, both hye and lowe"; and is accompanied by an index to "teche a man withoute tarying to fynd what meete that hym lust for to have."

The British bill of fare in good houses in Chaucer's time was marked by indications of plenty. The poet alludes to the franklin as "Epicurus' own son."

"Withouten bake meat never was his house
Of fish and fleshe, and that so plenteous
It snowëd in his house of meate and drink
Of alle dainties that men could of think.
Woe was his cooke but if his saucé were
Poignant and sharp; and ready all his geare."

It was not till the seventeenth century, however, that the artist-inventor cook sprang into existence, and then the Italians and the French began to lead the way with little touches of refinement in the shape of palate-ticklings that had never before been attempted. The potentates of the time encouraged this inventiveness in the kitchen, and the royal *cuisines* of England and France were given over to the new masters of the art to experiment in to their hearts' content. The example was followed far and wide, and cooks became once more a mighty power in the civilised world. In what high esteem cooks came to be held is attested by the remark which a French judge once made to the celebrated astronomer Laplace. He said, "I look upon the invention of a new dish as a far more interesting event for humanity than the discovery of a new star, inasmuch as we have already stars enough and to spare, but we could never have too many dishes." Even Dr. Johnson confessed that dinner was the most important occurrence of every day. No wonder that the cook flourished under these new conditions.

Solidity and abundance continued to be the motto of the English cook, for all that, and until quite recently the well-fed Briton persistently turned up his nose at dishes of foreign invention. Alexis Soyer, with much good sense underlying his bombast and great practical knowledge overtopping his vanity, did much to engraft French notions upon the English culinary art about the time of the Crimean War, and thereafter there was a great migration of French professors to this country, resulting in a general remodelling of native cookery. It was Soyer's ambition—and he partially realised it—to show how the plainest dishes might be made to savour of the richest viands; and, though the British cookmaid resisted these encroachments upon her insular prejudices most stubbornly, she had to give way, and the work of progress went steadily on in spite of her. Within the last quarter of a century a vast English literature of cookery has been built up, which many consider to embrace what is best in the culinary art of Continental nations, as well as to possess a character, power, and distinctiveness of its own. The ancient joke that "England had 120 religions, but only one sauce, and *that* melted butter," has long since been exploded; in fact, it was never true, for when the present century was but very young the following epigram (pointing at least to another) was current:—

> "Two Harveys had a secret wish
> To shine in different stations;
> The first invented sauce for fish,
> The second 'Meditations.'

One to good living was allied,
T'other to holy dying :
This relishes a sole when fried ;
That saves a soul from frying."

It may be questioned whether, with this and the hundred other sauce inventions which England now possesses, we have one that is quite equal to the French sauce which caused a Parisian gourmet to declare, "With a sauce like that a man might eat his own father!"

Invention is working in a thousand odd ways in these active days on behalf of the kitchen. There is a Paris *chiffonier* who has made his fortune out of collecting stale crusts, which he rebakes and grates for the use of cooks as "croûtes au pot." About a hundred substitutes for tea have been discovered, and coffee is being made out of acorns. Soup is said to be sold in Marseilles made from the fatty material skimmed from the water at the outlets of the drains; coffee-grounds purchased at French cafés and restaurants are put to a second brewing, and coffee for the street stalls is made from them ; and a thousand other apparently useless matters are utilised and innocently eaten by the unsuspecting citizens of the world. It may be in time that, in our constant craving for culinary novelties, the enterprising caterers of the future will introduce, under newfangled names, the dried elephant so much in favour in Siam, the birds'-nests so beloved by Chinamen, the tender young monkey which the African epicure delights in, the roasted grasshoppers of which the Californian miner makes a feast, the boa-constrictor which the native of Southern Guinea indulges in, or the spiders which the New Caledonians are so fond of, for the inventive genius now employed in aid of the kitchen is equal to anything in the way of culinary disguises.

There is no branch of the art of cooking in which greater strides have been made of late than in the art of preserving. This is the era of tinned meats. At first tinning was confined to the preserving of products from abroad, but now it has been extended, with beneficial results, in all directions, and we have tinned extracts of various meats, tinned meats *au naturel*, tinned milk, tinned fruit, tinned fish, tinned game, tinned everything. Tins and bottles fill our provision shops and our larders, with a result that the fruits of summer are available for the winter, and previously perishable dainties of tropical countries can be brought to our homes uninjured by their long voyage. The inventor has, indeed, produced so many changes in the modern *cuisine* that the Englishman of to-day can lay all the countries of the world under easy contribution for the furnishing of his daily banquet. No one, though, has yet invented an apparatus for doing without eating. The nearest approach to this seems to have been M. Soyer's proposals to Omer Pasha at the time when the French cook went over from England to see what he could do to help the commissariat. "Monsieur Soyer," said the Turkish General, "I have no doubt that, as regards cooking, you are a very clever man; but if you could manage to cook a dinner out of nothing, you would be more clever still." The *chef's* reply was characteristic of the man. "Not having tried the experiment," he said, "I really cannot say whether I could do so or not. But I will try, and then report progress to your Excellency."

CHAPTER XXII.

FOLLOWERS OF ORPHEUS.

The Music of the World of Nature—The First Musical Instrument—Drum-worship—The Invention of the Pipe—Its Developments—The "Minister of Love"—The Lyre, the Prototype of all Stringed Instruments—The Jew's-harp—Frederick the Great's Jew's-harpist—Accordions and Concertinas—The Jacquard Principle Applied to Musical Instruments—The Apollonicon—Musical Effects from Unmusical Materials—The Violin—Mystery of its Origin—The Great Makers of the Sixteenth Century—Antiquity of the Organ—Fantastic Organs—The Pianoforte, its Origin and Developments—Sebastian Erard—Music-Noting Machines.

IN the golden days, "when Music, heavenly maid! was young," the inventor did not, as in these later days, devote himself to the production of sweet sounds as a matter of profit or livelihood; he simply practised the art as an amusement. The world of Nature was full of music, from the dulcet trebles of the "melodious birds," which chanted their "madrigals" beside the singing waters, to the reverberant bass of the mighty thunders which shook the skies and filled the earth with awesome tremors; and it was as an imitator of these various sounds that man, in the dim prehistoric past of which the fossil world is our only record, began to make music on his own account. What those first instruments were we can only imagine, but it seems to be agreed on all sides that the drum must have been in the musical race from the beginning. It is the instrument of all others which most naturally associates itself with our ideas of the primitive state of things; it is the instrument of the untrained infant, and remains to this day the chief musical machine of uncivilised tribes. It can be traced through every historic age, now administering to the sensuous delight of an uncultured people, now having the attributes of a god assigned to it, as is exemplified in the drum-worship which prevailed in South America, when, from the Orinoco to the La Plata, the drum was the only object of devotional homage. The Mexicans were accustomed at one time to sacrifice the most beautiful youth in Mexico at the festival of Tezcatlipocas, the national god of music, to the rolling of a gigantic drum, the sound of which, according to the testimony of Bernal Diaz, could be heard eight miles away. In the gongs, timbrels, tabors, tambourines, and tom-toms of China, India, and other countries, we have a survival of the barbaric influence of this instrument, while in the musical displays of more advanced nations we either see the drum reduced to useful subjection to the harmonies of more refined instruments, or reserved for the noisier demonstrations of military life.

The next development of musical taste, after the drum, it has been held—and it is a pleasing fancy—was in imitation of the love-call of birds, and led to the invention of the pipe, the father of all wind instruments, which are now of endless variety, although for true musical sweetness the nearer we keep to the original form of the pipe, probably, the better. From the pipes of Pan, around which such lively poetic imaginings have been flung, to the brassy blare of the latest development of the horn, there is a vast and intricate maze of musical invention to be explored; but the landmarks are so few that it is difficult to connect dates and individuals with particular instruments until we reach a comparatively recent period. The trumpet, the sackbut, and the shawm, were amongst the earliest developments of the pipe, and were associated with the drum in manifesting the enthusiasm of triumph or enforcing terror. When the walls of Jericho were encompassed by the hosts of Israel, seven priests bearing seven trumpets of rams' horns marched round the city boundaries with the ark of the covenant, at Joshua's command, and, on the seventh day, after performing the circuit of the city seven times, the priests blew a final blast, and "the people shouted with a great shout, that the wall fell down flat, so that the people went up into the city, every man straight before him, and they took the city." We also read that Moses received the Divine command, when the Israelites were preparing for the journey from Sinai to Paran, to make two trumpets of silver "of an whole piece," for "the calling of the assembly and the journeying of the camps." There was also the feast of trumpets, "in the seventh month, on the first day of the month," when "no servile work" was to be done, and a burnt-offering "for a sweet savour unto the Lord" had to be made. The trumpet, and its kindred instruments, sounded the note of alarm as well as the note of joy, of retreat as well as of advance, and served almost all musical purposes except, perhaps, that of being the "minister of love." The cornet has in modern times often done duty as an instrument of the serenade, doubtless, but its ancient progenitor, the pipe, was the favourite instrument of the lover in that springtime of the world when all things were pastoral and primitive; and races still exist, away from the beaten track of progress, who have never advanced beyond the pipe stage of musical love-making. In Mexico a lover will pipe for many nights in succession beneath the window of the object of his adoration—until, indeed, his suit has been accepted or rejected. The Indians of the Upper Mississippi carry their courting-flute about with them, and the Formosans, Marquesans, and Otaheitians are all firm believers in the amorous influence of their native pipe. There are other races, however, who have recourse to wind instruments almost solely for purposes of alarm. The people of Tibet, for instance, we are told by M. Huc, use them for scaring away influences of an infernal character. "At stated times," he says, "four thousand Lamas assemble on the roofs of the various monasteries and blow trumpets and conch shells all night long to frighten away evil spirits."

The third stage of musical development, as far as regards instrumentation, is shown in the lyre, which is the leading idea of all stringed instruments. The devotional fervour of the Psalmist was attuned to the heavenly strains of the harp; floods of praise and affection, of passion and ecstasy, have been in all ages wrung from strings. Hermes Trismegistus is said to have made a lyre out of a tortoise-shell, on the banks of the Nile. The cithera of Eunomus must have been an adaptable instrument of this class. The story runs, that when he played upon it in the musical contest at the Pythian games, one of his strings broke; but that a cicada perched there, and by its notes supplied what was lacking. The varieties of instruments of the lyre order are infinite, extending from the Jew's harp to the grand piano, from the crude Chinese fiddle to the piano-organ of the streets.

It is to be regretted that the names of some of the

FREDERICK THE GREAT AND THE SENTINEL JEW'S HARPIST.

inventors of early instruments have not been preserved. It would be quite as interesting to know who was the inventor of the Jew's harp as to know who introduced, say, the euphonium or the saxe-horn into modern bands; but these things are hidden away in obscurity. The Jew's harp illustrates perfectly the principles by which musical sounds are produced; it is a lyre in miniature just as a piano is a lyre multiplied. There are no professors of the Jew's harp now. Since Frederick the Great showed something of his greatness by condescending to patronise so humble an instrument, no monarch has had the courage to attach a performer on the Jew's harp to his court. It is related that one evening Frederick was surprised at hearing exquisite musical sounds beneath his window, and looking forth saw a sentinel playing upon a Jew's harp. The King, as accustomed to command as to be obeyed, desired the soldier to come upstairs and play to him, but the sentinel replied that he could not do so without the colonel's leave. "But I am the king!" said Frederick. "I know it, sire," was the answer, "but if I leave my post to-night I shall certainly be punished to-morrow." Frederick was himself too good a soldier to press the matter further that night, but the next day had the instrumentalist up to play for him, rewarded him liberally, and gave him his discharge. Koch—that was the sentinel's name—subsequently played frequently for his Majesty, and travelled through Germany giving concerts as a player on the Jew's harp, making a moderate fortune by his skill. He could play on two Jew's harps at once, the sounds of which he could so modulate as to produce exquisite harmony. M. Eulenstein was another celebrated performer on this simple instrument. At his concerts, which he gave in every capital of Europe, he used no fewer than sixteen Jew's harps, playing two at a time, and changing from one couple to another with such rapidity as to cause no break in the music. He afterwards invented a system of playing four at once, connecting them by silken strings in such a way that he could clasp all four with the lips, and strike all the four springs at the same time.

A number of instruments in which springs or strings have been made to vibrate with pleasing effect have been invented in recent years, some being manipulated by the fingers, like the lyre, the harp, the guitar, the mandolin, the zither, and so forth ; some having the vibrating power supplied by wind, naturally or artificially brought into contact with the instrument, as in the case of the Æolian harp, the accordion, the concertina, the harmonium, and the organ ; and others depending upon the bow for the imparting of the necessary quivering motion, such as the violin, violoncello, etc. But the general principles of instrumentation remain unaltered.

Amongst the best known of distinct musical inventions of modern times may be mentioned the accordion, in which the wind is supplied by bellows, with finger-keys connected with valves, which produce the different notes, according to the action of the player's fingers. A decided improvement upon this was the concertina, the invention of Professor Wheatstone, in which, instead of keys to lift valves, were studs to be pressed in by the fingers, affording much greater facility of execution than had been possible with the accordion. The concertina, indeed, rapidly succeeded in making its way into popular favour, and may now be considered to have almost superseded the accordion. Other inventions of a kindred character have been introduced from time to time, and after attracting brief attention as musical curiosities, have dropped out of sight. The mouth harmonica, the symphonium, the seraphine, the æolophon, the æolodicon, the æolharmonica, the melodium, the melodion, the æolomusicon, were all ingenious modifications or expansions of previous ideas.

The principle of the Jacquard loom was applied to musical instruments in 1843 by M. Marlaveau, a Lyons silk manufacturer, and has since been variously used with good effect in enabling the unskilled by the mere turning of a handle to grind music of the most complicated character from keyed instruments. The antophon, which was shown in the Exhibition of 1851, was one of the first applications of this idea to be carried into practical effect. M. Debain, of Paris, also invented a piece of mechanism to which he gave the name of the *piano-mécanique*, in which similar results were obtained by different means. Boards studded with pins were provided, which on being placed on the keyboard and put in communication with a handle, which the player turned, would run off whatever composition the studs had been arranged to represent. The antiphonel was the name given to a similar apparatus intended for the organ. It is an adaptation of this mechanism which gives us the piano-organ of the present time, an instrument that, much as it is disliked by the fastidious, is a marked improvement upon the old barrel-organ, and does much to popularise the better class of light music.

Some years ago, an instrument of the barrel order was constructed by Messrs. Flight and Robson, to which the name of the apollonicon was given. It took five years to build, and cost £10,000. It was an organ that combined the effects of an entire orchestra, and could either be played by organists at the key-boards in the ordinary way—it had five distinct key-boards—or by an application of automatic power. It contained forty-five stops and 1,900 pipes, one of which was twenty-four feet in length by two feet in diameter. Many instruments of this kind have since been made, with movable barrels, capable of giving forth, with full orchestral effects, the most elaborate compositions, such as the more famous overtures of Mozart, Rossini, and Weber, with all the fortes and pianos, the crescendos and diminuendos perfectly expressed. Perhaps the prettiest things of this kind that have been made in modern times have been the delicately constructed musical boxes that Swiss makers chiefly have manufactured, in which steel springs acted upon by pegs have produced, in a kind of silvery echo, compositions of all descriptions, with accompaniments of drums, bells, or castanets, capable of being applied or shut off at will.

Much ingenuity, it is to be feared, has been wasted in producing musical effects from materials not usually regarded as possessing musical properties. Handel has given us an interpretation of what may be hit out from iron, in his "Harmonious Blacksmith," and Verdi, with his "Anvil Chorus," has followed that great master into the smithy with results more realistic if less musical. Glass has provided us with some pleasing touches of music, and even articles of the toilette have been laid under contribution occasionally for the production of melody. Sweet sounds have been derived from bits of stone, and in the East, from time immemorial, wood, in the shape of slips of bamboo, has been made available for musical purposes. Some quarter of a century ago, an instrument of the latter kind found its way into Europe from India, was improved upon by a Russian Pole named Guzikoff, and was taken up and still further bettered by M. Charles de Fry, chapel-master to the Archbishop of Cambrai. This instrument was styled the xylocarphon, and was composed of a number of sticks or cylinders of firwood or deal, strung together by violin strings and mounted on pieces of straw. The notes were struck with a couple of ebony sticks, and in the hands of a skilled musician like M. de Fry, the instrument was capable of discoursing very pleasing music. Something similar was invented by another French musician—a sort of dulcimer of pebbles. It is well known that there are certain pebbles which, if struck with another stone, emit a pure, clear sound, but they are so very rare that the inventor had to wait thirty years before he could secure the whole of the twenty-six pebbles he required to represent the tones and semitones of two octaves. Having completed his collection, he suspended the stones over a sounding board, arranged them to scale, and then began to play upon them. Two Frenchmen, the brothers Forre, invented a harp not long ago made entirely of wood, strips of American fir being used instead of strings. The player of this rather rough instrument had to wear leather gloves covered with resin. The tone was said to be of remarkable purity.

Of all the instruments of the lyre type, there is none that has achieved the eminence of the violin. Who its inventor was must ever remain a mystery, which is a pity, for if ever inventor deserved canonisation it was the genius who thought out this perfect instrument. Whether Apollo made music with the fiddle on Mount Parnassus, as early painters have represented ; whether, as some have asserted, this was the magic instrument which Orpheus used for bringing Eurydice back to life; or whether, as Tartini has related in serious prose, the devil amused himself by playing sonatas upon it (one of which Tartini reproduced, by the way), it is not fitting, perhaps, that we should inquire too searchingly; sufficient for us that the instrument dates back to the remotest period of antiquity, and that the modern inventor has never been able to improve upon it. More humiliating still, he has not even been equal to producing a copy of an old fiddle worth placing beside the original. Age and use, the enemies of all other instruments, improve the violin. Fabulous prices have been paid for some of the fiddles belonging to the celebrated makers of the sixteenth century, who are, perhaps, the only persons connected with the recorded history of this instrument whose claims are those of invention. For a violin by Steiner, the famous Tyrolese maker, it is said that fifteen hundred acres of American territory were once ceded, the value at the time being a dollar an acre. What that fiddle ultimately realised may be imagined when it is stated that the land which constituted its price is that on which the prosperous city of Pittsburg now stands.

The violin in its present form has existed from the eleventh or twelfth century. But it was in the sixteenth century that Amati of Cremona, and Di Salo of Brescia, by skilful shapings and combinations, gave the instrument the touch of perfection which made it the king and leader of all instruments of the lyre type. Then came Stradivarius, Guarnerius, Steiner, and other great makers, who all kept pretty much to the same model, and preserved from posterity certain secrets of manufacture which no amount of research, dissection, or analysing has been hitherto fully able to discover. Recent attempts to counterfeit the masterpieces of the great Italian makers have been partially successful, but no more. An improved bow is an invention of a later date, but in all else connected with the construction of the violin there has been distinct deterioration.

In other departments of musical mechanism invention has been more successful. The organ and the piano have especially benefited by the application of inventive skill. Musical authorities in speaking of the organ take us back to the time of "Tubal, the son of Lamech;" refer us to the invention of the water-organ by Ctesibius, of Alexandria, who had the advantage of the assistance of Archimedes in perfecting the instrument; and then, leading us through the maze of the musical annals of a less remote antiquity—when the organ was adopted as a sacred instrument, and received the patronage of the Popes and other dignitaries of the Church—bring us down to the Middle Ages, when it had taken something like the form which it wears to-day, with its mechanism of stops, manuals, and pedals, to which voice was given by bellows. There was the Duke of Mantua's organ mentioned by Prætorius, " of which the keys, pipes, keyboard, nay, even the outside of the bellows, were of alabaster ; " and there was an organ of silver built for the Escurial.

The fantastic period of the organ was the seventeenth and early part of the eighteenth centuries, when many childish inventions were made to do duty along with those portions of the instrument proper which constitute its chief power. Carillons, trumpets, and kettle-drums were played by automatic figures of angels; the organ was enclosed in a mock firmament, with musical suns, moons, and stars moving hither and thither; cuckoos, nightingales, and eagles were impersonated in ingenious mechanism; and, to crown all, there was a fox-tail stop, which the organist pulled out when any too inquisitive person came near, the tail suddenly flying into the intruder's face. A stop to imitate the sobbing, sighing, and trembling of a vast congregation was also used on special fast days. Since then there have been giants at work on the organ, and a succession of mechanical appliances has been invented for increasing the power of this instrument. The Haarlem organ, built by Christian Müller, was at one time the musical wonder of Europe; and the magnificent organs constructed by Gabelaar, Silbermann, and Father Schmidt, have attracted deserved attention; but it has been left for our own time to surpass these instruments in massive sonority of tone, in grandeur of construction, and, above all, in the introduction of particular mechanism by which the art of the player is greatly assisted.

The pianoforte has a still more interesting history. As the instrument of the drawing-room it has passed from inventor to inventor through a cloud of romance. In its most antique form it is too much mixed up with other instruments of the lyre order to be worth while tracing. We must come down to the fourteenth century to get at anything really tangible concerning it. We then find the clavicytherium, or keyed cithern, an established musical fact; and afterwards, by a regular gradation of improvements, we get the successive inventions of the cembalo of the Italians, mentioned by Boccaccio, the spinet, the virginal, the clavichord, the clavecin, the harpsichord, until we arrive at the pianoforte of our own time.

It was a Florentine in the service of the Duke of Tuscany who originally invented the pianoforte (the soft-loud), or, the forte-piano, as it was called in those days. There was a bit of romance connected with those times and the early pianoforte-makers, the Erards, which ought not to be passed over. Sebastian Erard, at the age of eighteen, left Strasburg, his native place, for Paris, where he bound himself apprentice to a clavichord-maker, soon proving himself so skilful as to excite the jealousy of his master. They quarrelled and parted, and Sebastian entered the service of another constructor of clavichords, who appreciated his skill so much that he set him to make an instrument that was to surpass everything that had up to that time been done in this line. Young Sebastian accomplished the task with complete success, and when his master took the clavichord to the purchaser and was asked to explain the mechanism, he was unable to do so, and was obliged to confess that Erard had made it. This invention was called the *clavecin-mécanique*, and at once procured the youthful mechanic the friendship of distinguished persons. The Duchesse de Villeroy offered him the hospitality of her house, which he accepted, and it was for her that he made his first piano, being spurred on to this effort by having had one of German construction brought under his notice. The piano he made was pronounced to be a distinct improvement upon the German instrument. Orders pouring in upon him altogether beyond his power of production, he took his brother, John Baptiste, into partnership, and they established themselves in Paris as makers of pianofortes. Their rivals in trade did their utmost to injure them, and would have succeeded in their work of persecution but for the intervention of the King, who issued a brevet of protection for the Erards, which recognised the merits of Sebastian's "invention to improve the instrument called a forte-piano," which had "even obtained the preference over those made in England." The chief improvement in the piano effected by Sebastian Erard was the double escapement. He also invented the double action of the harp, by which he made a fortune. In the first year after he had patented this invention he sold £25,000 worth of the new harps in London alone.

Soon after reaching Paris, as a young man, he went one Sunday to the gates of the Château de la Muette, at Passy, in the hope of seeing Marie Antoinette ride out in her carriage. When the queen came into sight he shouted "Vive la Reine!" and her Majesty, attracted by his powerful voice and Alsatian accent, spoke to him, asking him to what country he belonged. "I am French at heart by my birth, as your majesty is by your marriage," was his gallant reply. The Queen granted him permission to walk through the grounds, a privilege which he availed himself of with eager delight. A few years' later he had the honour of making a piano specially adapted to the limited compass of Marie Antoinette's voice. In 1823, Sebastian Erard was himself the purchaser of the Château de la Muette, for ever associated in his mind with the memory of the ill-fated Queen whose kindness had made so deep an impression upon him when a young man and a comparative stranger in Paris. He died in 1831, his last work having been the grand organ which he built for the chapel of the Tuileries.

There have been many other men of inventive genius who have devoted their talents to the improvement of the pianoforte. It would be impossible to indicate the details and extent of a tithe of the mechanical contrivances which even the last quarter of a century has seen brought forth. Improvements in structure, tone, compass, expression, and pliability have been effected until it would almost seem that invention could not go any further with this instrument, unless some genius could imagine a method of producing sustained tones.

Before quitting this subject we ought perhaps to make mention of a series of machines which were invented in the last century for noting down music as any one could play it upon a keyed instrument. Beckmann makes particular reference to these curious but not much utilised machines. One, John Freke, transmitted a paper to the Royal Society in 1747, describing such an apparatus, the invention of a clergyman named Creed. About the same time a German, John Frederick Unger, hit upon a similar idea, and secured the approval of the Academy of Sciences at Berlin for his machine. Another German, named Hohfeld, took the matter up at this point, and made an instrument with the same object. Dr. Burney aroused the indignation of Beckmann by claiming the merit of this invention for the Englishman Creed. But he hardly need have excited himself about the matter, as after-events have proved that not one of the machines was capable of being brought into practical use.

CHAPTER XXIII.

IN FIRE AND SMOKE.

The Fires of Nature—Metallurgical Operations of Early Times—The Ironworkers of the Sussex Weald—From Wood Furnaces to Coal—Dud Dudley's Smelting Process—The Ironworkers of the North—Huntsman's Steel Ingots—Huntsman's Mysterious Visitor—Sir John Brown—From Apprenticeship to Knighthood—Introduction of Rolled Armour-plates—The Romance of the Lamp-light—Invention of Coal Gas—Murdoch's Experiments—Winsor, the Dreamer—Something like a Prospectus—London Lighted by Gas—London's Gas Bill—The Oil Regions of America—Young's Paraffin—A Valuable Patent.

FROM heat proceeds all power. When the latent fires of Nature were first set aflame by primitive man he touched the life-spring of civilisation. From that time to the present, fire has been working its way through all the phases of the development of human progress. As the genial warmth spread itself from object to object, and its vitalising force began to be gradually realised, extraneous means were resorted to for obtaining a still fiercer heat, and the bellows was invented. The wind would point the way to that. Then followed the acquirement of a knowledge of the processes of melting and smelting, leading by slow degrees to the establishment of various metallurgical operations. The path was thus prepared for Tubal Cain and the artificers in metals generally, and so the power of fire came to be exerted upon the metals and minerals one by one, until man grew skilled in the making of utensils of numberless descriptions, and the iron, brass, tin, and steel trades rose into prominence amongst the industries of nations.

The processes seem to have remained much the same for thousands of years, and the Romans found in many parts of this country, but principally in Sussex and Kent, everything ready to their hands for iron-making. But, by-and-by—centuries after the Romans had yielded up their conquests—a new fire-producing power was discovered in the beds of coal underlying vast regions of the earth's surface, and a great impetus was given to metallurgical operations.

The furnaces of wood had been kept burning briskly and incessantly in the Weald of Sussex for some hundreds of years, there being no fewer than 140 furnaces for iron-smelting in that county in the sixteenth century, each furnace consuming 200,000 cords of wood per annum. But when "pit-cole and sea-cole, for the preservation of wood and timber of Great Britain so greatly consumed by ironworks," got fairly into use, the ironworks of the coal-producing districts began to flourish and those of Sussex to fall into disrepute. Simon Sturtevant, in 1611, procured from the King a patent "for the said metallical businesses for one and thirty years," in order "to neale, melte and worke all kinde of mettle oares, irons and steeles, with sea-coale, pit-coale, earth-coale, and brush fewell." Unfortunately, Sturtevant failed, as did his successor John Rovenson. Dud Dudley then came upon the scene and succeeded in establishing the utility of coal as a fuel for smelting furnaces. It was not all "plain sailing," however, for Dud Dudley; his new method was strongly opposed, and he suffered not a little persecution. He published his "Metallum Martis" in 1665. The Coalbrookdale blast-furnaces began to use coked coal in 1735, and from that time the growth of the iron trade was exceedingly rapid. It would be a long story to tell how the various improvements in the metallurgic processes from that time to this, from Dud Dudley to Bessemer, were introduced. A portion of the story is told in other chapters of this volume. Henry Cort, Josiah Marshall, Heath, Neilson, Siemens, Bessemer are amongst the illustrious names in this tale of fire and smoke. There are, however, a few bits of romance which it may be well to pick out from this outwardly forbidding region.

When once the burning of coal had been begun in England it soon spread into all avenues of industry, and the increased demands upon the coal supply have been brought about by many curious inventions. At Attercliffe, near Sheffield, in 1760, there lived a watchmaker named Huntsman, whose temper had often been tried by the defective quality of the watch-springs then in use. He sometimes wondered if it were not possible to make these articles homogeneous, and at last came to the conclusion that if he could only melt a piece of steel and cast it into an ingot, its composition would be the same throughout. He made a few experiments, and succeeded beyond all expectation. Then he began to offer his steel ingots for sale, and such a demand was created for them that he had to set up a manufactory for their production. How he made them, what mysterious elements he brought into operation, or by what strange process of metallurgy he reached this astonishing result could not be discovered. The trade were in a complete fog concerning it; but Huntsman preserved his secret, and fenced it round and round with protective barriers, all the time building up for himself a handsome fortune.

It was about 1770 when he set up his manufactory, and the workmen engaged were paid high wages, and sworn by the most terrible oaths never to divulge the nature of Huntsman's new process of making cast steel. All went well until one winter evening when, as the furnaces of the Attercliffe works belched forth their tongues of smoke and flame, a stranger halted at the gate and rang the bell. The snow was falling fast, the wind howled dismally across the moorland, and it was bitterly cold. When the gate was opened, and the stranger, who was dressed in the garb of a farm labourer, made a piteous appeal to be allowed to shelter for a while from the storm, the foreman, after scanning the man closely, took him in and offered him his generous sympathy, without a suspicion that the visitor was any other than he represented himself to be. The poor fellow, seemingly worn out with cold and fatigue, stretched his weary limbs upon the floor, within the warm glow of the furnace, and to all appearance sank off to sleep. Meanwhile, the workmen were busy with their casting operations. They cut the bars of steel into small pieces, threw the bits into the crucibles, thrust the crucibles into the furnace, applied the blast to the roaring fires, and then waited until the steel was melted. Still the farm-labourer slept on. Then, the furnace-men, protecting themselves as best they could from the fierce heat, drew the glowing crucibles forth, poured their liquid contents into moulds, and the steel was set apart to cool into perfect ingots. Soon afterwards the stranger was observed to get up. He had almost been forgotten in the excitement of the casting operations; at all events, it had not been noticed that the supposed farm-labourer was only pretending to sleep, and that there was not a single detail of their work that he had not carefully observed. They gave him a cheery good-night as he ventured forth again into the storm, and wished him a safe journey home. And he went, taking the secret of cast-steel making with him. There were many manufacturers of cast-steel in Sheffield after that; and Huntsman no longer held the key of the position.

Another story not without its romance belongs to a later phase of Sheffield's special industries; this is the story of Sir John Brown. John Brown was of humble parentage, and worked his way to manhood as an apprentice to the cutlery business. Subsequently he was enabled to secure a partnership in the steel trade by the aid of relatives, who guaranteed £500 for him to one of the local banks. In 1848 he invented the conical spring buffer for railway trucks, by which, after a long struggle to gain the patronage of the railway companies, he ultimately made a fortune. In 1864 he purchased the now famous Atlas Works, and there founded the first Sheffield ironworks. Up to that time he had been using an immense quantity of steel and iron, most of which he got from Sweden; but it now occurred to him that Yorkshire might be made available for all his requirements, and he was soon a more prosperous iron-maker than he had been a steel merchant and buffer patentee. The great event of his life, however, occurred in 1860, when Mr. Brown took a short holiday on the Continent, returning home by way of Toulon. The French man-of-war *La Gloire*, carrying an armour-plate four-and-a-half inches thick, was at that time lying in the harbour, and excited much attention, for it was the first of the new era of iron ships of war. Mr. Brown began to pry into this mailed mystery of the deep, and would fain have boarded the monster if the French officials had not resolutely kept him back. He sailed round and round the ship, and before he came away had seen enough to give him a brilliant idea for making a further fortune. *La Gloire's* plates were hammered; Mr. Brown thought they could be produced better, stronger, and cheaper rolled. He was scoffed at, of course; the thing was deemed impossible; but he set to work to prove the contrary, and, after an expenditure of £10,000 in experiments, he was able to exhibit a rolled iron plate five inches thick, three feet wide, and twenty feet long.

He now approached the Admiralty; but it was a long time before the practical mind was able to convince the unpractical that the rolled plate was as good as the hammered. The Government at last sanctioned a series of experiments, Lord Palmerston himself visited Sheffield and saw the rolling processes in operation at the Atlas Works, and in the end the Lords of the Admiralty gave large orders for the supply of armour-plates of the new kind. But all this time Armstrong, Whitworth, and others were improving the strength of guns and projectiles, and it seemed as if shipbuilding had got to the point at which it would not be possible any longer to withstand the thunders of the mighty ordnance of war. The Government despaired; but not so John Brown. He tried to cheer them on to further resistance by offering to produce an armour-plate that the heaviest gun should not be able to shatter. The performance was equal to the promise. Plates were rolled that no shot was able to penetrate, and the work of armour-plating was allowed to proceed. The gigantic achievements since then in plate-making throw the plates of *La Gloire* far into the shade. There are ironclads to-day sailing the seas encased in suits of iron armour twenty-two inches thick. A knighthood was surely no more than was the due of the man who wrought all these wonders, and the £1,000,000 that the limited liability company gave him on buying him out was equally well earned.

The iron trade is full of romances of this kind; but we must turn from them at present, to glance at the picturesque subject of illumination.

Lamplight, in one form or another, has kept back the terrors of darkness through all the centuries of recorded time. Still, there was not much improvement in this illuminating power until the early years of the present century were reached. Between the light of the lamps used by the Egyptians on the festival of Minerva of Saïs, that of the seven-branched candlestick of the Tabernacle, that of the rope-suspended lanterns of the ancient Romans, and that of the oil-lamps of London and Paris in the eighteenth century, there was no great difference of power. Beckmann, writing in 1786, said, "The lamps of London at present are all of crystal glass; each is furnished with three wicks; and they are affixed to posts placed at the distance of a certain number of paces from each other."

But, long before this, inflammable coal-gas had been known, although it took many years to bring it to the point of utilisation. Towards the end of last century several people were found experimenting with this gas—Mr. Spedding, of Whitehaven, who lighted his office with it, and Mr. William Murdoch, who, in 1792, employed coal-gas for illuminating his house and offices at Redruth; but it was reserved for Mr. Winsor to give the idea more permanent shape. Murdoch had what he considered weightier matters to attend to in connection with Boulton and Watt's famous steam-engine enterprise; Winsor, on the other hand, gave himself up almost solely to working out the one idea of street illumination by coal-gas.

There was a good deal of the dreamer about Winsor, and his inflated style of putting his scheme before the British public did not propitiate his audience. Still, much as he was ridiculed and abused, and much as he over-estimated the profit-yielding capacity of the new illuminant under commercial guidance, he did manage to force it into adoption, and to him belongs the credit of having been the first to light a London street with gas and the first to make gas-lighting a branch of commerce. In 1803 and 1804 he lighted the Lyceum Theatre with gas, and on a certain night in 1807 one side of Pall Mall was made to burst into luminous glory by means of this new flame. Winsor was completely carried away by his project, and wrote prospectuses and issued explanatory statements calculated to put to shame even the imaginative flights of the company-floaters of to-day. The joint-stock company which was formed to carry out Winsor's scheme was styled the National Light and Heat Company, and the profits to accrue, according to Winsor's own elaborate calculations, would yield "over two hundred and twenty-nine millions of pounds!" Giving over "nine-tenths of that sum towards the redemption of the National Debt, there would still remain a total profit of £570, to be paid to the subscribers, for every £5 of deposit!"

A patent was taken out by Winsor for the invention, and the company made an application to Parliament for liberty to proceed with the scheme, but were opposed by Boulton and Watt, and the bill was thrown out at the time, though a newly-constituted company that took over the old one was more successful in the following year. They had to wait a long time, however, for the coming in of Winsor's promised £229,000,000, for they were several years before they could pay any dividend at all, the opposition and prejudice being so strong. But Winsor had supreme confidence in himself and his projects from first to last. "All gas-lights," he wrote, "shown and exhibited before my illuminating the large theatre in the Lyceum, early in 1804, I fairly consider as so many *Will-o'-the-wisp* lights, known for centuries past;" after which he went on to set forth that while the methods of others had been to collect gas "in bladders in marshy ground," he had shown them the art of applying coal-gas, of saving, analysing, preserving, refining, and storing it; and he referred in the most contemptuous terms to the "theorists who could write but not practise," and "whose delicate hands and noses would have shrunk in horror from his numerous dirty and laborious experiments in kitchens and wash-houses, where his own labourers complained of being suffocated, and often refused to assist him, until he shamed them by the example of stripping, to perform what they thought was too dirty work for them." He adds, with characteristic grandiloquence, "Animated by the life and example of Peter the Great, Emperor of all the Russias, who performed the most abject labours to teach his ministers and generals how to civilise a barbarous nation, I did no longer deem it beneath me (who had been a merchant in the city of London) to do that work which some of my labourers, actually in want of bread, refused to do for victuals and payment."

It was not Winsor, for all that, who made the gas undertaking a paying one. Mr. Samuel Clegg, who had been in the service of Boulton and Watt, and had had the advantage of special instruction in gas-lighting from Murdoch himself (the actual inventor), was employed by the leading gas company to take the practical management of their concern, and he succeeded in introducing many improvements and putting the enterprise on a paying footing. At first the gas was stored in bags; gasholders were adopted under Mr. Clegg's *régime.* Winsor dropped out of public view shortly after this, and retired to France, where he died, being buried in Père-la-Chaise. The new light soon spread over all the country when once its feasibility, cheapness, and profit-yielding capacity were demonstrated, and now there is hardly a village in the remotest wilds that has not its gas-lights. The city of its birth, London, pays over three millions a year for its gas bill to-day, and consumes over 21,000,000 thousands of cubic feet of gas. A few years ago the electric light threatened to supersede the gas lamps, but that point of practicability which means success has not yet been reached, although the more powerful illuminant is extensively used in large establishments and in the streets of many cities, particularly in the United States.

Surely there is romance, too, of a rugged, but still wonderful, kind, in the discovery and working of the great petroleum fields of North America, when there was a rush to the Pennsylvanian oil regions almost similar to the rush for gold to California, or for diamonds to the Cape, and fortunes were made with unheard-of rapidity by simply boring a hole in the earth and letting the oil gush forth. The first great oil boring was made in 1859, at a place afterwards called Oil Creek, where 1,000 gallons a day were extracted for many weeks. One of the chief wells yielded 25,000 barrels a day for a considerable time. It has been said that there are in the oil districts of the United States supplies of petroleum sufficient for the illuminating oils of the whole world for centuries.

The discovery made in a Derbyshire coal mine in 1847 by Dr. (afterwards Sir) Lyon Playfair of an oily spring that seemed very similar to petroleum, was taken advantage of by Mr. James Young, to whom Playfair mentioned the matter, and whom he commissioned to make investigations. Young invested all his money in this mine, and worked the oil until the yield was exhausted; then, with the world to face anew, he set himself to experiment with coal, having the idea that the petroleum was the distilled vapour of the coal, heated by subterranean fires, and condensed by contact with the stone above it. For two years he experimented, first with one kind of coal and then with another, until he ultimately found that a mixture of cannel-coal and soda-ash would yield him what he had been seeking. He took out a patent for his process in 1850, and set up works at Bathgate, in Scotland. From that time Young's paraffin, both as an illuminant and a lubricant, came into general use, and the inventor died a millionaire.

Such are some of the romances which are to be found in the annals of fire and smoke.

CHAPTER XXIV.

INVENTORS IN BOOKLAND.

Paper-trade of Ancient Egypt—Invention of Parchment—Early Paper Makers—Gutenberg and Fust—William Caxton—An Excellent Man of Business—The First English Paper-mills—The First Printed Newspaper—The Stanhope Press—The Steam Printing-press—Frederick Koenig—Improvements by Applegarth and Cowper—Colonel Hoe's Invention—The Walter Press—The Literature of the United Kingdom—The Newspapers of the World.

AGES before the art of printing was known, the paper trade was a flourishing industry, and books were produced in large numbers. So well did paper-makers thrive in ancient Egypt that one Firmus was able to raise the standard of revolt against the Emperor Aurelian, and boasted that he could maintain an army solely from the profits of his trade; and as for the makers of books, the scribes, they were probably as well paid a body of men as existed in the olden time away from the posts of civil and military preferment. Papyrus manuscripts have been found in Egypt, the age of which has been estimated at over three thousand five hundred years; and the substance was in general use in Greece in the time of Alexander the Great. Various historians have endeavoured to trace the making of papyrus back to still earlier dates, but there is a suspicion of the apocryphal about most of these statements. Parchment was a later invention, in which a King of Pergamus, in the time of the Ptolemies, is said to have been concerned; but Herodotus speaks of the Ionians having used the skins of goats and sheep for writing upon prior to that period. The next period, and the most important of all up to that time, in the direction of book-making, was the invention of a method of making paper from rags. To whom this invention was due is an undiscoverable secret. The Chinese seem to have been early in the field as paper manufacturers by pulping, and from them the art travelled westward until it reached Europe about the year 900. Spain was the first of the European nations to adopt the new process; France followed in 1260; Germany in 1312; and England some time in the fifteenth century.

Up to this time all books were in manuscript, and many beautiful specimens of such works exist, with illuminated titles, headings, and initials most exquisitely wrought in colours. But a new light broke in upon the darkness towards the close of the fourteenth century. A method of printing playing-cards by blocks was discovered in Germany about that period, and this seems to have suggested to Gutenberg the possibility of adopting some similar method for the production of books. He experimented a considerable time with movable types before he succeeded in the task he had set himself. Gutenberg was a native of Mayence, but was living in Strasburg in 1439, and there he began his labours. In 1448 he returned to Mayence, with his mind full of his invention, and obtained the assistance of a rich goldsmith named Fust in perfecting it. The two entered into partnership, and about the year 1450 Gutenberg began printing with his movable types what is now called the Mazarine Bible, which was finished in 1455. This was a great achievement, but it brought him more trouble than profit, unfortunately; for Fust and he quarrelled respecting pecuniary matters, and the partnership between them was dissolved.

Gutenberg and Fust now ran rival establishments; the former starting another press at Mayence in conjunction with a Dr. Hummer, and printing a magnificent work called the "Catholicon"; while Fust took Peter Schöffer into partnership, and carried on the original business. So the two concerns continued for a few years, both obtaining a fair amount of work, and attracting to themselves a good deal of notice, though neither they nor the public thoroughly appreciated the importance of the invention. The chance of war favoured the dissemination of the art. Mayence was besieged by the followers of Archbishop Adolph II. and the workmen of the two printing establishments left the city, taking with them the knowledge of their art. In this way printing soon came to be adopted in other places, and spread over Europe generally. Gutenberg contented himself with entering the service of Adolph II., with whom he remained until his death in 1468. A monument was raised to him by a friend. It bore the following inscription:—"To Johann Gensfleisch [this was the name that Gutenberg was known by], inventor of the art of printing, deserving well of all nations and languages; Adam Gellhuss has erected this monument to the immortal memory of his name. His remains rest peaceably in the church of St. Francis, at Mayence." A claim has been advanced on behalf of Lawrence Coster, a native of Haarlem, as the inventor of printing, but it rests on no reliable proof. There is, indeed, little doubt, that this art was the invention of Gutenberg.

In England the new art was taken up by William Caxton, who, having served a few years as apprentice to a London mercer, was sent abroad "to obtain experience in trade," after the fashion of the time. He took up his abode in the Low Countries, and at Bruges rose to be a merchant trader of some repute. For the long period of five-and-thirty years he remained in the old Flemish town, and in 1471 he is found occupying a position of trust in the household of the Duchess of Burgundy. It was about that time that he first turned his thoughts seriously towards literary matters, and began translating into English the "Recueil des Histoires de Troye," a French historical romance. He finished his task at Cologne on the 19th of September, 1471, and presented the translation to his mistress, the Duchess, who "largely rewarded" him for it. When his work was done it was much sought after, and Caxton "promysid to dyverce gentilmen" and to his friends to "addresse to them as hastely" as he might "this sayd book"; but, he says, "for as moche as in the wrytyng of the same my penne is worn, myn hande wery and not stedfast, myn eyen dimed with ouermoche lokyng on the whit paper, and my corage not so prone and redy to laboure as it hath ben, and that age crepeth on me dayly and febleth all the bodye," therefore, "I haue practysed and lerned at my grete charge and dispense to ordeyne this sayd book in prynte after the maner and forme as ye may here see, and is not wryten with penne and ynke as other bokes ben, to thende that every man may have them attones, ffor all the bookes of this storye named the recule of the historyes of troyes thus enpryntid as ye here see were begonne in oon day, and also fynisshed in oon day."

It is considered probable that this first book of Caxton's was printed at Bruges, about 1474. His second was "The Game and Playe of the Chess," also printed abroad. Three years later we find him back in England, established at Westminster as the first English printer, and enjoying the patronage of Margaret, Duchess of Somerset, mother of King Henry VII. Although he had reached the mature age of sixty-five when he settled down within the precincts of Westminster Abbey—probably in a house known as "The Red-pale," in the Almonry—to this "vertuous occupacion and besyness," he applied himself so zealously and industriously to his project that during the next fifteen years of his life he printed no fewer than sixty-four different works, including the Psalter; "The Chronicles of England;" "The Canterbury Tales," and other works of Chaucer; the "Confessio Amantis" of Gower; "King Arthur," and "Æsop's Fables." Many of the books printed by Caxton were translated by himself from the French.

Caxton must have been an excellent man of business and something of a courtier into the bargain. Edward IV., Henry VII., Earl Rivers, the Earl of Warwick, and the Earl of Arundel were amongst his patrons, and, although the time was one of political turmoil and civil dissension, he contrived to prosecute his labours without interruption and without falling under the displeasure of any party. The work that he was engaged upon represented human progress, and the leaders of the time saw fit to recognise the fact, with the exception of some of the Romish ecclesiastics, one of whom is represented as having said, "We must root out printing, or printing will root us out." So, aided by his trusty servants, Wynkyn de Worde and Pynson, the Father of Printing continued to carry on this important trade, buying his paper from the paper-makers of Burgundy, but acting as his own type-founder, ink-maker, and wood-engraver. All these operations were successfully prosecuted within the shadow of the ancient abbey, and when, in 1492, Master Caxton was laid at rest in the parish church of St. Margaret's, and the bell was tolled and the torches burnt for his funeral, his contemporaries mourned his death and honoured his memory for the good work he had done in establishing printing as one of the English arts.

From Caxton's time onward printing was gradually developed as an art, and attracted to itself many notable men, giving a widespread impetus to literary effort. The first paper-mill erected in England has been commonly believed to have been that of John Spielman, a German, who established one at Dartford in 1588, and had the honour of knighthood conferred upon him by Queen Elizabeth, as well as a license granted to him "for the sole gathering for ten years of all rags, &c., necessary for the making of such paper;" but there occur several allusions to the existence of paper-mills in England before that date, not the least interesting of which is that of Shakespeare in the second part of the play of *Henry VI.* (Act iv., Scene 7), where Jack Cade is made to charge Lord Say with having, amongst other offences, "caused printing to be used, and, contrary to the king, his crown and dignity, thou hast built a paper-mill." There is evidence, however, of a paper-mill having been in existence at Hertford in Caxton's time—the Seel mill, carried on by John Tate, which was considered of sufficient importance to be visited by Henry VII.

There was a long interval between the first printed book and the first printed newspaper. The *Venetian Gazette* was established in 1620, and in 1622 the *London Weekly Courant* made its appearance. The *London Gazette* was started in 1642, and still exists as the only English official paper published in this country. From that time weekly journals increased in number and importance, although a temporary check was given to the development of newspapers by the prohibition to publish them in 1680. But this edict did not remain long in force, and when it was withdrawn, the work of journalism was resumed with increased vigour. The first English daily paper, the *Daily Courant*, was brought out on the 11th March, 1702; it was announced as "being designed to give all the material news as soon as every post arrives, and is confined to half the compass, to save the public at least half the impertinences of ordinary newspapers." For forty days this single-page paper continued to be published, and after that date it passed into the hands of Samuel Buckley, the printer of the *Spectator*, and was enlarged to two pages. Newspapers now continued to increase in number, size, and importance year by the year. The *Times* was first published on the 1st of January, 1788.

As far as the printing-press was concerned very little improvement had been effected. It remained in much the same condition as when Caxton used it until the Earl of Stanhope, in 1798, introduced his iron press, by means of which 250 impressions per hour were capable of being turned off. This was a great stride of advancement, but a greater still was effected when, on the 28th of November, 1814, the *Times* was first printed by a steam press which yielded 1,100 impressions per hour.

Dr. Smiles has told the story of the life of Frederick Koenig, the inventor of this machine. He was a native of Eisleben, having been born there in 1774. In 1802 he was working as a journeyman printer in Leipzig, and in the following year started in business as a printer and bookseller in his native town. His undertaking was unsuccessful, so he removed first to Mayence, and afterwards to Suhl in Thuringia, employing much of his time in thinking out improvements in printing. "He contrived an improved press," writes Smiles, "provided with a movable carriage, on which the types were placed, with inking rollers, and a new mechanical method of taking off the impression by flat pressure." He travelled from place to place trying to get printers to take up his invention, but without the least success, and was just thinking of making his way to England, as a last resort, when there came an offer from the Russian Government for him "to proceed to St. Petersburg and organise the State printing-office there." In the spring of 1806 Koenig landed in the city of the Czar, and assumed the duties of his new appointment; but Russian officialism made matters so unpleasant for him that he did not hold the post many months. His next move was in the direction of England, where he arrived in November, 1806. For a time he maintained himself by working as a journeyman, but, full of his invention, sought to press it upon the acceptance of various printers. While thus engaged he made the acquaintance of his countryman, Andrew F. Bauer, who possessed a more complete knowledge of mechanics than Koenig. A partnership was struck up between them, and the first result of their combined working was seen in a machine for which they took out a patent on the 29th of March, 1810. The first work that this machine performed was in April, 1811, when it printed 3,000 copies of one of the sheets of the "Annual Register" for 1810, at the rate of 800 impressions per hour.

There was still much to be done before the invention realised expectation, and Koenig was himself too poor to continue the work without pecuniary help. A partnership was therefore effected for the purpose of bringing the invention forward to the point of success. Mr. Thomas Bensley, the printer, had been connected with Koenig almost from the first, but Messrs. Taylor and Woodfall were now induced to join in the enterprise, and a factory was established in Whitecross Street, with Bauer as manager, for the making of machines on Koenig's principle. The proprietors of the principal newspapers were now approached in the matter, but all fought shy of the new machine except Mr. Walter of the *Times*, who was far-seeing in this as in other business affairs; in fact, he had been on the look-out for a steam-printing press for some time, and had opened up negotiations which came to nothing with more than one inventor before Koenig came upon the scene. Mr. Walter was favourably impressed by Koenig's machine, and "ordered two double machines for the printing of the *Times* newspaper." Numerous improvements were necessary to meet Mr. Walter's requirements, but these were in the end successfully accomplished, and, as we have already seen, the *Times* was, in 1814, printed on one of Koenig's presses, and the steam-printing press became an established fact. The invention was secure, if not the inventor. Indeed, Koenig fared badly all through. He had trouble with his partner, Bensley, and with rival inventors, who, under the pretence of introducing improvements, contrived to possess themselves of the leading principles of the new press, and made Koenig's patent an almost worthless property. No wonder that he returned to his native country in despair and disgust, and had the remainder of his life saddened by the recollection of the ill-treatment he had been subjected to by those in whom he had placed trust and confidence.

He settled at Obezell, near Würzburg, where he was joined by his old friend Bauer, who brought with him "an order from Mr. Walter for an improved *Times* machine, and the two men entered into a partnership which lasted for life." Little by little their business increased, and in 1829 the firm employed 120 men. Koenig died in 1833; Bauer lived until 1860; and the business which these two men established was afterwards carried on with enlarged success by the sons of Koenig.

The steam printing-press having been once established, soon underwent a rapid improvement. Messrs. Applegarth and Cowper introduced the "perfecting machine" in 1818, by which both sides of the paper could be printed simultaneously, thus doubling the productive power. A four-cylinder press was afterwards designed, in 1823, which enabled from 4,000 to 5,000 sheets per hour to be printed; and in 1846, Mr. Applegarth introduced what was called the vertical cylinder machine, with eight cylinders, equal to the work of printing 10,000 sheets an hour. Then came the invention of Colonel Hoe, of New York, who introduced the system of placing the types in segments upon a horizontal cylinder. This machine increased the velocity still further, an output of 19,200 impressions per hour being reached, or "about 16,000, including stoppages." A still more important improvement was brought about by the adaptation of the stereotyping process to the steam printing machine. By this system an impression is obtained in stereotype metal from each "forme" of type, and the stereotype is curved to fit the printing cylinder. These stereotype plates can be multiplied to any extent, and distributed amongst any number of machines, all of which may be engaged at the same time printing similar copies. The next development of newspaper-printing machinery was the Walter Press, which was the result of several years' intelligent experiment. This press prints from a continuous web of paper, each of which is four miles long, and feeds the machine in much the same way as a cotton warp feeds a loom. It prints the paper on both sides, and cuts and folds each single sheet in one operation, its action being completely automatic. It can work off in an ordinary way 12,000 copies an hour of an eight-page paper, or, at a push, 17,000 copies. The Walter Press was introduced in 1869. Steam-printing is now in operation everywhere, both for newspapers and books. It has had the same effect upon the literature, as the steam-engine has had on the industries, and as the locomotive has had on the traffic of the world.

In the United Kingdom alone considerably over 2,000 newspapers are now published, including ninety daily papers, and some 5,000 new books are issued every year from the printing presses of Great Britain. Four hundred years ago paper-mills were few and far between; there are now said to be 3,985 paper-mills in the world, making 1,904,000,000 lbs. of paper every year, half of which is used for printing. The consumption has been averaged as being 11½ lbs. per annum for each Englishman, 10½ lbs. for an American, 8 lbs. for a German, and 7½ lbs. for a Frenchman.

Taking the whole world, we have a total number of 35,000 newspapers and other periodicals, or one to every 28,000 inhabitants. Europe has 20,000 newspapers, Germany coming first with 5,500, of which 800 are published daily, the oldest being the *Post Zeitung*, first issued at Frankfort in 1616. Great Britain follows, then France, then Italy, Austro-Hungary, Spain, Russia, Greece, Switzerland, Holland, and Belgium (which brings up the rear) in the order named. Asia has about 3,000 journals, of which no fewer than 2,000 appear in Japan; Africa has some 200 papers, 30 of which are published in Egypt; and in South America, the Argentine Republic takes the lead with 60 newspapers. The United States possess about 12,500 periodicals, of which at least a thousand are published daily, the oldest being the *Boston News*, which was first issued in 1794. It is a somewhat curious fact that America has 120 papers edited and published by negroes. Eight papers are published in the Sandwich Islands.

These are some of the evidences of the development which the invention of Gutenberg has wrought in the world; the rest of the testimony is written in the social, moral, and intellectual development of the world's inhabitants, and represents a gradual but rapid progress from the outer darkness of feudalism to the brilliant light of the highest civilisation hitherto attained.

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